Author:
Passenger, Terri

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The contribution of phonological awareness and phonological memory to early literacy.

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Terri Passenger

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Terri Passenger

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ABSTRACT

This dissertation investigates the development of phonological awareness and phonological memory and their relative contribution to early literacy. The literature review suggests that despite extensive research interest, clear understanding of phonological awareness has been impeded by inconsistent definitions and methods of assessment. Phonological memory deficits have typically been attributed to poor readers, but the contribution of phonological memory to early literacy has been less well documented.

Research data are presented from a longitudinal study of 80 children as they began to learn to read. The children were assessed at three points over an 18 month period. At the first stage of testing the children were attending a range of pre-school centres and were all at a preliterate stage of development. The second stage of testing occurred six months after school entry and the final stage of testing was at the end of the first year of formal schooling.

Tests in phonological awareness, phonological memory, alphabetic knowledge, speech rate, spelling, reading and general verbal ability were administered. The results indicate that phonological awareness and phonological memory both play an important part in the development of early literacy and make significant contributions to the acquisition of alphabetic knowledge during the first year at school. Evidence is presented which suggests that at a preliterate stage, rhyme awareness and phonological memory may reflect one unitary skill which contributes to the use of a phonological recoding strategy in early literacy. Alliteration appears to reflect a different skill and makes a separable contribution to reading and spelling attainment. From the data it would appear that a quantitative and qualitative change in memory function occurs during the first year of formal schooling.

The theoretical and practical implications of the findings together with suggestions for future research are discussed.

Declaration

The work contained in this thesis is that of the author.

The views expressed here are also those of the author and not those of the University of Bristol.

signed Terri Passenger

Terri Passenger

date 4.2.97.

Acknowledgement

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CHAPTER 1

PHONOLOGICAL AWARENESS

Introduction and Outline of Chapter

Although claims have been made for an association between phonological awareness and reading achievement, academic study of phonological awareness is fraught with debate and confusion. This is in part caused, as Fox (1991) suggests, by the lack of consistency with which researchers define and measure phonological awareness.

In order to examine the relationship between phonological awareness and reading, and ultimately the relationship between more general phonological processing abilities and reading, three areas need to be discussed

- how phonological awareness has been defined in the literature
- how phonological awareness has been measured
- what the proposed relationship is between phonological awareness and reading

This chapter will review the literature on phonological awareness and will argue that imprecise definitions and diverse task types have impeded understanding and confounded comparisons between studies. These issues will be discussed under the following headings:

- the nature of phonological awareness
- the levels of phonological awareness
- the development of reading
- reading acquisition and instruction
- knowledge of the alphabet
- phonological awareness and reading
- phonological awareness and spelling

1.1 The Nature of Phonological Awareness

The proposed association between phonological awareness and progress in learning to read has been described rather grandly as 'one of the great successes of modern psychology' (Goswami & Bryant, 1987, p. 439). From this, phonological awareness could be interpreted as an homogenous skill. However, definitions of phonological awareness are inconsistent, encompassing a general '<u>sensitivity</u> to the sound structure of one's language' (Mattingly, 1972), to an ability to ' <u>reflect explicitly</u> on the sound of spoken words' (Hatcher, Hulme & Ellis, 1994) to an ability to 'identify and <u>manipulate the individual phonemes</u> in words' (Torgesen, 1991) (author's emphases). In addition, Tunmer and Rohl (1991) assert that,

> Phonological awareness is .... awareness of phonemes. It is not an awareness of syllables, awareness of intrasyllabic units, or awareness of words. (p. 8)

A broad range of tests has been employed to assess the proposed component sub-skills of phonological awareness. These vary in the length of speech unit to be judged (syllable, rhyme or phoneme) and the cognitive demands of the tasks themselves: counting or adding syllables (Liberman, Shankweiler, Fischer & Carter, 1974; Stuart & Coltheart, 1988); detecting or producing rhymes (MacLean, Bryant & Bradley, 1987); or adding, deleting or substituting phonemes (Bradley & Bryant, 1983; Bryant, Bradley, MacLean & Crossland, 1989; Stanovich, Cunningham & Cramer, 1984).

It could be argued that results from different tasks have 'shaped' the definitions: for example, an ability to identify a single sound in the speech stream would prompt a definition of phonological awareness as 'an awareness of phonemes' (for example, Stuart & Coltheart, 1988). Conversely, it could be that the tasks employed in any one study may be dependent on the definition of phonological awareness adopted. Quite distinct tasks would appear between a study which set out to investigate a general sensitivity to the sound structure of language (for example, MacLean et al., 1987) and a study which aimed to assess the ability to manipulate phonemes (for example, Bruce, 1964). This may be one explanation for declarations that phonological awareness is both precursor to and consequence of reading acquisition (Bradley & Bryant, 1983; Morais, Cary, Alegria & Bertelson, 1979).

Task performance appears to differ between studies and the next section considers the cognitive and linguistic levels of phonological awareness.

1.2 The Levels of Phonological Awareness

It could be argued that early research into the relationship between phonological awareness and reading failed to discriminate between types of phonological tasks (Lewkowicz, 1980). Inconsistencies in methodologies and age ranges in these early studies have resulted in confusing interpretations of the component skills of phonological awareness together with differing assessments of the contribution made by these skills to reading development. In order to clarify the situation, several attempts have been made to determine whether phonological awareness is a global or a composite skill. Additionally, a number of efforts have been made to assess the relative contribution of such skill at different points in reading development.

1.2.1 Multiple Task Studies

In one study, Stanovich, Cunningham and Cramer (1984) administered a battery of ten different tests to a group of 49 kindergarten children (mean age 6.0 years). These included tests of rhyme production and detection, phoneme substitution, isolation and deletion. Performance on the phonemic tasks showed a significant intercorrelation and, when a reading test was administered a year later, a significant correlation was found between phoneme detection tasks and reading ability. However, several children in this study were already readers and, as the IQ measure was not entered into the multiple regression analysis before the scores for phoneme detection, the association claimed in this study between phonological awareness and reading may have been spurious. Factor analyses of the data revealed that the non-rhyming tasks loaded on a single factor and all were moderately related to reading achievement. Scores on the rhyme task appeared to suffer ceiling effects and, it could be argued, this may explain the lack of correlation between the rhyme tasks and the phonemic tasks.

Yopp (1988) administered an extensive battery, which included both auditory discrimination and learning tests, to a large cross-sectional sample of 104 kindergarten children (mean age 5 years 10 months). The learning test trained and then assessed the children's ability to decode a set of non-words using sound-symbol correspondence. The ten 'phonemic' tests (p. 159) incorporated tasks used in earlier research, together with others specially modified or constructed for this study. Scores from the sub-tests of phoneme blending, counting, deletion, segmentation, matching and identification were significantly correlated but the correlations between these and the rhyming task ($r = .42$ to $r. = .55$, $p < .001$) were reported to be only 'moderate' (p. 169). A ranked classification of the tasks suggested rhyming to be the easiest and phoneme deletion to be the most difficult. When the data was subjected to factor analysis, two factors accounted for 69% of the variance. Yopp examined the cognitive demands in each factor by task analysis and proposed a clear delineation between Factor 1 tasks, such as phoneme blending, which demanded one operation and Factor 2 tasks, such as phoneme deletion, which demanded several operations and therefore imposed a greater memory load. Rhyming was not found to load on either factor and prompted Yopp to conclude that rhyme tasks may tap a different underlying ability, quite unrelated to phonemic awareness. From the presented evidence, Yopp recommended that a combination of tests, one *simple awareness* task from Factor 1 and one compound *awareness* task from Factor 2, should offer greater validity in assessing phonological awareness and subsequent reading ability.

The proposed predictive association between the phonemic tasks in this study and subsequent reading was based on Yopp's individually constructed 'learning task'. It could be argued that this 'learning task' was itself a grapheme-phoneme training programme; as no reading test, measure of IQ or test of alphabetic knowledge was tested at the outset, it may well be that some of the children, tested towards the end of the school year, were already reading or able to apply an alphabetic strategy to the 'learning task'. Based on the low correlation between scores on the rhyme task and the other phonemic tasks, Yopp warned, 'generalisations about phonemic awareness drawn from research which focuses on rhyme tasks should be considered with caution.' (p. 172). This would seem to illustrate an important point, not least in the importance of correct terminology. '<u>Phonemic</u> awareness' (under which 'umbrella' term all the <u>phonological</u> tasks in this study are subsumed) relates to an awareness of single sounds or phonemes. Both this study and the earlier study by Stanovich and his colleagues (1984) suggest that rhyme and phonemic awareness represent separable components of phonological ability and that awareness of rhyme precedes awareness of the single phoneme. It would seem feasible that '<u>rhyming</u> ability', which refers to sensitivity to a larger unit of speech, the 'rime', may, therefore, represent another <u>level</u> of phonological awareness and it would be inaccurate to assume 'phonemic' awareness from rhyme tasks. In line with this, Goswami and Bryant (1990) have subsequently proposed that rhyming and phonemic ability may make different contributions to reading development.

Yopp's factor analysis discriminated between tasks from a cognitive-demand perspective; Morais (1991a) also discriminated between different levels of phonological awareness, this time based on the <u>linguistic</u> analysis demanded by the task. He proposed a clear distinction between implicit (or holistic) and explicit (or analytic) phonological awareness. Implicit awareness, Morais (1991b) suggested, is a sensitivity to 'suprasegmental properties' (p. 35). The term 'segmental' is taken here to mean 'phonemic'. Adopting this definition, implicit awareness can be seen as a sensitivity to segments of speech larger than phonemes. Syllables are larger than phonemes and, as they correspond directly to articulatory gestures, demand no analysis of the speech stream and are therefore the easiest units of speech to identify (Liberman & Mattingly, 1985). For example, the word *cat,* which centres on the peak of acoustic energy in the speech stream, is heard as one sound (the syllable *cat*) as all three phonemes (*c-a-t*) are co-articulated. Implicit phonological awareness is thought to be sufficient for tasks which demand comparisons or appreciation of the surface sound structure (Morais, 1991b). Explicit phonological awareness, however, requires deeper analysis of the speech waveform as in phonemic sensitivity. Unlike syllables, phonemes do not correlate directly with acoustic peaks in the speech stream (for example, articulation of the medial vowel *a* in *cat* is influenced by the preceding *c* and following *t*) so a more abstract awareness of phonological structure is required. It has been argued that such *explicit* awareness does not occur before six years of age when the phonological system of language is fully developed (Fowler, 1991).

Discrimination between levels of phonological awareness is evident elsewhere in the literature (Cataldo & Ellis, 1990; Treiman & Zukowski, 1991). However, there are again discrepancies in definition of the levels of phonological awareness assessed by different tasks. For example, Yopp's (1988) suggestion that phoneme segmentation should be considered a measure of *simple phonemic awareness* would not appear consistent with Cataldo and Ellis' (1990) claim that 'successful performance of phoneme segmentation tasks requires an *explicit* awareness of individual sounds within words' (p. 8). Treiman and Zukowski's work (1991) has attended particularly to the linguistic levels of phonological awareness. Discussion of tasks in terms of the linguistic units to be judged would seem to be a more straightforward approach than attempting to address the proposed simple/compound or implicit/explicit levels of phonological awareness.

The next section reviews a range of studies which, it has been claimed, provide convergent evidence that phonological awareness follows a developmental continuum (for example, Bryant & Bradley, 1985; Muter, 1994) and that linguistic demands within the tasks influence the strength of the relationship with subsequent reading ability.

Research into phonological awareness has embraced a broad range of tasks, some of which focus on one specific linguistic level and other developmental studies which assess a range of levels simultaneously. From the literature, studies working with young children typically include assessment at the syllabic level.

1.2.2 Awareness of syllables

Studies of phonological awareness in the 1970s assumed, and focused on identifying, two levels of phonological awareness: awareness of syllables and awareness of phonemes. Results from one influential study (Liberman, Shankweiler, Fischer & Carter, 1974) indicated the ease with which children as young as four years were able to identify syllables. In this experiment a tapping game was employed where the experimenter spoke a word or sound and a small sample of children ranging from four to six years of age were asked to tap the number of either syllable or phoneme sized units. Half the total sample completed the syllable tapping and half completed the phoneme tapping. Table 1 shows the percentage of children at each age who were successful in identifying the two units of speech.

Table 1 Percentage of children achieving criterion of six consecutive correct trials in the phoneme and syllable segmentation tasks (Liberman et al., 1974)

	Syllable	Phoneme
4 years	50%	0%
5 years	50%	17%
6 years	90%	70%

The results were interpreted as evidence of a developmental continuum of phonological awareness where syllabic awareness precedes phonemic awareness. No details were given regarding selection of the groups and, as there was no measure of IQ, it is therefore uncertain how well-matched the groups may have been. At the same time, the correction of the children's errors during testing, whilst providing information on the percentage of errors, could well have provided a training effect: this is supported by evidence that scores improved over the duration of the test.

Support for this developmental pattern of phonological awareness comes from a study by Stuart and Coltheart (1988). As part of a longitudinal study, a sample of 23 pre-schoolers (age range 4.5 years - 4.9 years), were asked to supply only the final sound in naming a set of plastic toys. Eight items had monosyllabic names, for example, *dog* or *duck* and demanded a phonemic final sound, and eight had di-syllabic names, for example *zebra* or *carrot* and demanded a syllabic final sound. Table 2 illustrates the differential ease with which the children were able to complete the syllabic task.

Table 2 Mean scores (standard deviations) for 'Supply Final Syllable' and 'Supply Final Phoneme' tasks (based on Stuart & Coltheart, 1988)

	Syllable	Phoneme
N items	8	8
Mean	6.6	2.1
SD	2.3	2.7

From the results of multiple regression analyses in their study, Stuart and Coltheart (1988) found that phonological scores were not predictive of subsequent reading after nine months in school but, combined with IQ, were predictive of reading at the end of the second year in school. This contrasts with other findings of a significant correlation between one aspect of early phonological skill, syllabic awareness, and reading one year later (Mann & Liberman, 1984; Mann & Ditunno, 1990). However, in the study by Stuart & Coltheart, (1988) scores on the syllabic, rhyme and phonemic tasks were amalgamated to give one generalised 'phonological score' although as the table shown here (Table 2) suggests there may have been ceiling and floor effects on two of the three tasks. In order to determine whether different phonological skills are relevant to reading at different stages of development it may be important to enter scores from individual phonological tasks separately in any analyses.

From the literature, some of the most influential studies of phonological awareness have been those which have identified the importance of young children's sensitivity to rhyme.

1.2.3 Identification of Rhymes

There is some evidence that older children with reading problems are insensitive to rhyme (Bradley & Bryant, 1978) and a series of studies has proposed a significant relationship between pre-school sensitivity to rhyme and progress in reading (Bradley & Bryant, 1983; 1985).

Awareness of the prosody or rhythmic pattern of speech is thought to develop from the child's earliest linguistic experience in routine encounters with poems, songs and even advertisements (Trevarthen, 1987). Words which rhyme, it has been claimed, have the same phonological pattern from the stressed vowel and an ability to remember familiar rhymes demonstrates an awareness of this shared sound pattern within words (Adams, 1990).

1.2.4 Identification of Nursery Rhymes

Linguistic routines such as repeating nursery rhymes are commonly cited in studies of young children's language acquisition (for example, Trevarthen, 1986; 1987). In addition, evidence from one study has suggested that this early knowledge of nursery rhymes may play a signifcant role in the development of phonological awareness.

Results from this longitudinal study by Bryant, Bradley, MacLean & Crossland (1989) provided some evidence of a significant correlation between nursery rhyme knowledge at three years of age and later reading achievement. Despite the relatively high mean IQ of the sample, this relationship remained significant even when IQ and social background were controlled. However, the direct relationship between nursery rhyme knowledge at three years and reading at six years was no longer significant when rhyme scores at five years were entered as the first step in the analysis. This would suggest that tests of rhyme ability, rather than nursery rhyme knowledge, may be more predictive of subsequent reading ability with children from four years of age.

The controversy surrounding the nature of the association between general phonological awareness and reading has already been noted. However, whilst results from a number of studies would seem to consistently suggest an association between rhyme and reading (for example, Bradley & Bryant, 1983), closer examination of the studies reveals a marked variation in both task demand and methodology. These inter-task variations could account for the apparent discrepancy in results between studies which have assessed rhyme sensitivity. From the literature, three task types commonly appear: rhyme detection, rhyme production and rhyme oddity.

1.2.5 Rhyme Detection

Rhyme detection or rhyme classification tasks have been used in a number of studies. One of the earliest studies (Lenel & Cantor, 1981) used a 'forced-choice' methodology. Triplets of monosyllabic words were presented to 144 children (age range 4.02 years - 7.5 years) who had to determine which of the two trial words rhymed with an initial stimulus word. Half the trials used picture cards and half involved auditory presentation only. In the test design, the non-rhyming word in each trial was categorised according to the degree of formal similarity shared with the stimulus word. For example, the non-rhyme *can* shared two sounds with the stimulus words *cat*, while the non-rhyme *pen* had no sounds in common with *cat*. The results indicated the influence of the stimulus vocabulary: trials in which the stimulus word and non-rhyming response shared two phonemes (*cat, can*) were more difficult. The results were interpreted as evidence that children as young as four years were sensitive to rhyme. The cross-sectional design of the study also led Lenel and Cantor (1981) to propose that rhyme sensitivity develops gradually rather than resulting from an abrupt transformation from chance to perfect performance. Based on the high percentage of correct responses in the four year old group (76.9%), Lenel and Cantor (1981) claimed the forced-choice rhyme recognition methodology to be more appropriate for young children than the previously employed 'yes-no' paradigm (Chapman, Calfee & Venezky, 1970).

It is difficult to determine why results from the Lenel and Cantor (1981) study should be so markedly different from those of Chapman in the earlier study (1970) in which the children also had a one-in-two chance of giving a correct response. As Lenel and Cantor (1981) failed to assess IQ or reading ability, it could be the samples were not matched or that some children were already reading. Rhyme awareness indicates a sensitivity to the sounds following the stressed vowel: the sensitivity to the initial and medial phonemic similarity in *cat* and *can* would seem to provide further evidence that the children in this study had a more analytic awareness of individual sounds in words.

As discussed earlier, Yopp (1988) found her rhyme detection task, modelled on an earlier 'yes-no' design (Calfee, Chapman & Venezky, 1972) to be unrelated to the other measures of phonological awareness. In her study twenty word pairs, taken from a list of high frequency words (Thorndike & Lorge, 1963), were orally presented for the child to determine whether the two words rhymed. Another study employed a similar task with younger children, (Stuart & Coltheart, 1988) but again varied the methodology. This time word triplets were presented visually on picture cards which the children had to name for themselves and then decide whether the three words rhymed by answering 'yes' or 'no'. Corrective feedback was given throughout the ten trials. The vocabulary this time included rhyming words for example, *key, bee, tree/ jar, car, star* together with non-rhyming words which differed by both medial vowel and final consonant, for example, *cup, mouse, doll/gate, horse, leaf.* In contrast to the earlier study (Lenel & Cantor, 1981), the results from the Stuart and Coltheart study suggested a bimodal distribution (mean 6.1; SD 4.6). The significant correlation between the rhyme tasks and the other phonological tests contrasts with the lack of correlation proposed by Yopp (1988). As Yopp reported the rhyme task to be the easiest, it could be argued it was too easy for children who were two years older than those in the Stuart and Coltheart study and that the lack of correlation was caused by ceiling effects in Yopp's rhyme task.

These studies would seem to suggest that verbal or visual presentation of stimuli should be a consideration in test design. Rhyme sensitivity or detection would also appear to be an appropriate task for testing phonological awareness in very young children.

1.2.6 Rhyme Production

Dowker's (1989) study reported the ability of children as young as three years of age to produce both word and non-word rhymes as part of their oral language games. Rhyme production tasks have most typically been used in studies with young children to assess this proposed level of phonological awareness. Despite these claims by Dowker (1989) and MacLean, Bryant and Bradley (1987), results from other studies incorporating a rhyme production task suggest that young children may find rhyme production considerably more difficult than rhyme detection. In one study (Stuart & Coltheart, 1988), rhyme production scores (max = 8; mean score 4.6; SD 3.5) were lower than rhyme detection scores (max = 10; mean score 6.1; SD 4.6). A more recent study (Muter, Snowling & Taylor, 1994), found that four year olds were able to produce a mean score of only 1.1 (SD 1.7) when asked to produce as many words as possible in 30 seconds which rhymed with two orally presented stimulus words. This 'floor effect' was not evident, however, from the rhyme detection task in the same study where the mean score over 10 items was 5.5 (SD 2.9).

As neither study gives information regarding IQ or verbal ability, it could be argued that the children who scored well on the rhyme production task were simply those who had more substantive vocabularies. The difference in scores between the two studies would seem to suggest there were differences in general ability between the two samples. However, it is interesting to note the differences in the methodologies employed. Both studies used picture cards for the rhyme detection task but, for the rhyme production task in the earlier study (Stuart & Coltheart, 1988), the children were given picture cards from which they were required to teach rhymes to a puppet. The later study (Muter et al., 1994) employed only oral presentation of the stimulus words. It could be argued that the children in the earlier study (Stuart & Coltheart, 1988) were more motivated by interacting with a puppet and this may have contributed to the significantly better scoring than in the later study (Muter et al., 1994).

1.2.7. Rhyme Oddity

In an influential longitudinal study, Bradley and her colleagues (1983; 1985) investigated the relationship between rhyming skill and reading development in a large sample (n = 403) of four and five year old children. The sound categorisation task included in the test battery employed a method used previously by this group (Bryant & Bradley, 1978). The task involved the auditory presentation of three words (for four year olds) and four words (for five year olds) from which the child had to indicate the 'odd-man-out' or the word which did not share a common phoneme in the specified place. A test of verbal intelligence was administered together with a memory measure to control for the memory load in this auditorily presented task. Mean scores for the identification of a different final sound were found to be higher on initial testing than identification of different first sound. Scores for identification of a different medial vowel were found to be consistently higher still. Results from this study suggested a significant correlation between sound categorisation and reading ability three years later even when effects of variation in IQ and memory were taken into account.

The memory load in this task was considerable but it is questionable whether the memory measure taken (asking the children to repeat the stimulus words from the 30 trials) was appropriate. In the memory task, the child was required to repeat a string of three or four words whereas the rhyme task itself asked the child to hold all three or four words in memory, carry out a sound categorisation operation and then articulate the response. A later study with young children by the same group (Bryant et al., 1990) included picture cards 'to remove the memory load' (p. 431). The choice of vocabulary in the earlier study may also have influenced the results. The children in that original study (1983) were asked to identify the odd man out from *bus, bun, rug* (first sound), *cot, pot, hat* (medial sound) and *pin, win, sit* (final sound). The choice of vocabulary in the task meant that the middle and final conditions were testing the same ability, namely rhyme, and the similarity in scores for the two conditions is clearly shown in Table 3. However, the mean scores for initial sound categorisation differed considerably from those for categorisation of the middle sound and final sound.

Table 3 Mean scores for the Sound Categorisation task (based on Bradley & Bryant, 1983)

	4 years*	5 years**
	mean score max = 10	mean score max = 10
First sound	5.69	5.36
Middle sound	7.53	6.89
Final sound	7.42	6.67

* auditory presentation of three words per trial
** auditory presentation of four words per trial

This study was important in demonstrating a close association between early rhyming ability and subsequent literacy: the combined 'sound categorisation' scores from this study were found to account for up to 10% of the variance across measures of reading and spelling taken four years later. The original results, however, (Table 3) would seem to indicate that awareness of the first sound (alliteration) may represent a separate skill or level of phonological awareness. Studies which have failed to support the close association between early rhyming and later reading have generally involved testing older children aged six or seven years (Stanovich, Cunningham & Cramer, 1984; Yopp, 1988), so it would seem that for very young children, aged between four and five years, rhyming tasks may be more potent predictors of subsequent reading attainment.

1.2.8 Identification of Onsets and Rimes

Most studies of phonological awareness have compared two linguistic units, the syllable and the phoneme. The influential work of Liberman (1974) discussed earlier together with a number of other studies have consistently reported the proficiency of young children in syllable awareness tasks rather than phoneme awareness tasks (for example, Fox & Routh, 1975). However, according to Treiman and Zukowski (1991) these studies have focused on the syllable and the phoneme by adopting a linear model of syllable structure where the syllable is implicitly assumed to be an unsegmented string of phonemes. The linear model for the word *cat* is illustrated in Fig. 1.

Fig. 1 Linear view of the English syllable structure (adapted from Treiman & Zukowski, 1991)

syllable		*cat*	
phoneme	*c*	*a*	*t*

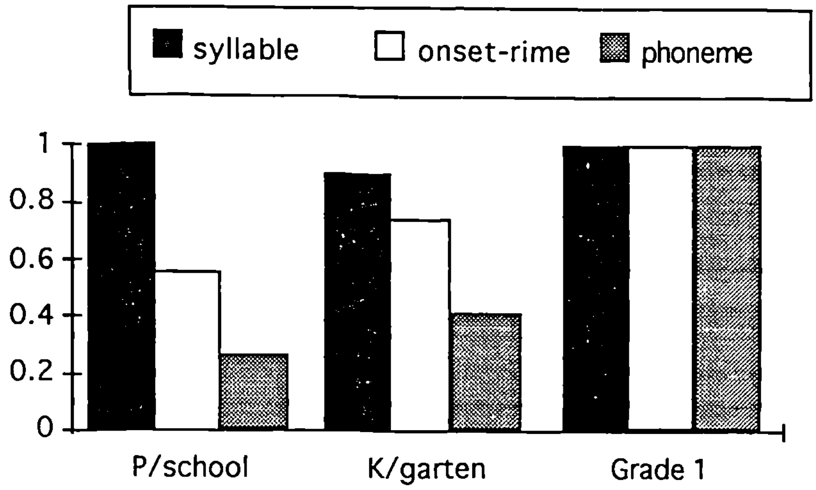
In a series of experiments (1983; 1985; 1986; 1988), Treiman has provided some evidence for an alternative hierarchical view of syllable structure which, she argues, is more correctly founded on linguistic and psycholinguistic research. Halle and Vergnaud (1980) observed that, in articulation, monosyllabic words are naturally divided between the consonant which precedes the vowel (the onset) and the subsequent sounds (the rime). Speech errors such as spoonerisms are most commonly cited as evidence of this natural onset-rime coding, where 'Don't shout' and 'Don't yell' are more readily combined to give 'Don't shell' than to give 'Don't shoull' (Mackay, 1972). Adopting this hierarchical model, the word *cat* may be broken into subunits, smaller than a syllable yet larger than an individual phoneme. The hierarchical model for the word *cat* is illustrated in Fig. 2.

Fig. 2 Hierarchical model of the English syllable structure (adapted from Treiman & Zukowski, 1991)

syllable			*cat*		
onset-rime		*c*		*at*	
phoneme	*c*		*a*		*t*

In order to investigate the awareness of young children to the phonological structures of syllable, onset-rime and phoneme, Treiman and Zukowski (1991) conducted a study with a large sample of children (n= 160; mean age range 5 years 1 month - 7 years 0 months). The proportion of children who responded correctly to six consecutive trials at a specific word length is shown in Table 4.

Table 4 Proportion of children reaching criterion of six consecutive correct responses on tasks of syllable, onset-rime and phoneme awareness (based on Treiman & Zukowski, 1991)



These results were taken to illustrate a developmental pattern for phonological awareness where onset-rime awareness is seen as an intermediary step between rhyme and phoneme awareness. As each child served in a single condition only (that is they were assessed for syllable or onset-rime or phoneme awareness), it should be noted that this claim for a developmental pattern is based on a group mean rather than an individual score. As reading ability was not assessed at the outset, it could be argued that the sample contained some readers who may have been using an orthographic rather than a phonological strategy to classify some words. The combined scores in this study failed to indicate whether judgements of rime were easier than judgements of onset.

To investigate the onset-rime structure further, Kirtley, Bryant, Maclean and Bradley (1989) gave initial and end sound oddity tasks to groups of five, six and seven year old children. The results indicated that both the readers and the non readers from the groups found it easier to identify a single sound in the onset than a single sound in the rime. This led Kirtley and her colleagues to claim that even pre-readers are able to classify words on the basis of common phonemes when they constitute the onset of the word. However, no measure was taken of letter-sound knowledge at the start of the study and it is possible that the pre-readers were using an alphabetic strategy to classify initial sounds. The close association between final phoneme identification and reading was taken as an indication that '.. a major step in learning to read may take place when the child learns to break the rime into smaller units' (Kirtley et al., 1989, p. 245).

This awareness that the speech stream may be broken into smaller units has most often been assessed by measures of phonemic sensitivity.

1.2.9 Identification of phonemes

Several studies have proposed a strong association between phoneme awareness and subsequent literacy development (for example, Calfee, Lindamood & Lindamood, 1973; Muter et al., 1994; Stanovich et al., 1984; Treiman & Baron, 1981). However, several of these studies suggest that the major contribution of phonemic awareness to reading development does not become apparent until the second year of schooling (Bryant & Bradley, 1985; Cataldo & Ellis, 1990; Stuart & Coltheart, 1988). As in the assessment of the other levels of phonological awareness discussed earlier, a diverse range of tasks and methodologies has been reported in the literature on phonemic awareness.

One of the earliest studies by Liberman and her colleagues (Liberman et al., 1974) included a task in which a combined sample of nursery, kindergarten and first grade children was asked to tap out the number of phonemes in a spoken word. Whilst the results suggest the task was too difficult for the nursery children (mean age 4.01 years), some association was proposed between results from the tapping task in kindergarten (mean age 5.10 years) and subsequent reading in Grade 1 (mean age 6.11 years). However, as no measure was taken of IQ, this evidence is not conclusive: the better readers may arguably have had better general cognitive abilities. The marked improvement in scores on the phonemic task during the first year of formal schooling could also suggest that phonemic awareness, rather than predictive of subsequent reading ability, develops more as a consequence of learning to read.

In another study, Tunmer and Nesdale (1985) worked with 63 six year old children, asking them to tap out the phonemes in a series of words and non-words. This time, when differences in verbal IQ were taken into account, phoneme tapping was reported to account for 21% of the variance in reading scores. However, as the sample included some children who were already reading, again it cannot be discounted that phoneme awareness may occur largely as an effect of learning to read.

Phoneme deletion is consistently claimed to be one of the most difficult phonological awareness tasks for beginning readers. A task devised for an early study by Bruce (1964), in which children were asked to delete the first, the middle or the final sound from a stimulus word, has been adapted in several studies. The results are shown in Table 5.

Table 5 Summary of results (mean scores) from the Phoneme Deletion task used by Bruce (1964)

	5 years	6 years	7 years	8 years	9 years
N	4	12	16	25	10
trials	30	30	30	30	30
mean score	0.0	1.8*	8.75*	16.4*	26.7*

* No standard deviations were reported

From the results of her study, Bruce concluded that phoneme deletion tasks were inappropriate for use with children under the age of eight years. This claim must however be weakened by the comparatively small size of the sample in this study.

However, similar 'floor effects' were noted in the phoneme deletion task included in a larger, longitudinal study (Muter et al., 1994). The comparable results from this later study are shown in Table 6.

Table 6 Summary of results (means and standard deviations) from the Phoneme Deletion task used by Muter, Snowling & Taylor (1994)

	4 years	5 years	6 years
N	36	36	36
trials	10	10	10
mean score	0.4 (1.5)	2.4 (3.8)	5.2 (4.4)

Based on the results of her study, Muter concluded that phoneme deletion tasks may be usefully employed with six year old children, but are inappropriate for use with four year old children.

The seemingly better performance of the six year old children in Muter's (1994) study could again be a reflection of differences in task design. For example, Bruce (1964) administered thirty trials, while Muter (1994) administered only ten trials: ten trials would seem more appropriate taking account of the limited attention span of very young children. It could be further argued that differences in the linguistic structure of the stimulus words may have influenced the results. In the Bruce (1964) study, twenty five of the thirty stimulus words demanded a genuine phonemic deletion, for example, *spin-pin*; however, five could have been solved by onset-rime sensitivity, for example, *jam-am, nice-ice, near-ear, cold-old, hear-ear.* Stimulus words for the later study (Muter et al., 1994) were chosen from a corpus of spoken vocabulary in five year old British children (Raban, 1988). As only one example is given of the ten test items, *bus-us,* it is possible that this task was more a measurement of awareness at the onset-rime level than at the phonemic level.

This importance of the stimulus vocabulary was identified post-test from another study of phoneme deletion in six year old children (Bryant et al., 1990). The exact vocabulary used is not reported, but the linguistic structure of the stimulus words caused the authors to discount five of the ten trials as 'words with blended consonants were too difficult and we dealt only with the CVC scores in each task' (p. 431). Arguably here again, comparatively good performance on the first sound deletion in a CVC (consonant-vowel-consonant) condition (max = 5; mean 2.28) could reflect an ability to segment the onset and rime rather than true phonemic awareness.

One of the most frequently used tasks aimed at identifying phonemic sensitivity has been that of alliteration. Alliteration, defined as sensitivity to the first sound in a word, appears in a number of studies under a broad range of titles.

Most influential of the alliterative tasks has been the 'Odd-One-Out' or oddity task used in a large longitudinal study (n = 400) of four and five year old children (Bradley, 1980; Bradley and Bryant (1983). The task was administered in three conditions where the child was asked to identify either the distinct final sound, for example *pin/win/sit* or distinct medial sound for example, *cot/pot/hat* or distinct initial sound *hill/pig/pin.* Results across both age groups suggested that the children found identification of a different initial phoneme more difficult that identification of a different medial or final phoneme.

In the study reviewed earlier (Stuart & Coltheart, 1988), the alliteration/oddity task appears under the title of 'Segment Initial Phoneme'. Results from this longitudinal study of 23 four year old children however were markedly different from those of the earlier work by Bradley and Bryant (1983). In the later study, the task differed in that it employed picture cards to compensate for the presumed memory load of the former auditorily presented task. The child, presented with four pictures in each trial, was asked first to reject the semantic distracter, for example given *pink/blue/purple/pen* the child would reject *pen*, and then to reject the phonemic odd-man-out, in this instance *blue.* Despite the apparent similarity of the tasks, there was some discrepancy in results between the studies. The mean scores on the Bradley and Bryant trials (1983) were considerably higher (max = 10; mean 5.69; SD 1.90) than in the later study (max = 8; mean 2.9; SD 3.2) (Stuart & Coltheart, 1988). Two reasons for this could be proposed. First, although both sample groups were reported to be non-readers, it cannot be assumed they were matched in intellectual terms: the mean score on the English Picture Vocabulary Test for the sample in the first study (Bradley & Bryant, 1983) was 110.62, but no initial measure of IQ was taken in the second study.

The second possible cause could relate again to the linguistic structure of the stimulus words. In each of the ten trials in the first study (1983), Bradley and Bryant spoke three words all of which began with single phonemes, for example *hill/pig/pin* In the later study by Stuart and Coltheart (1988), four of the eight trials included words which began with sound-blends, for example *pear/grapes/peach* . Studies by Treiman and her colleagues (Treiman & Baron, 1983: Treiman & Zukowski, 1988) have suggested that four year old children can isolate the first sound in a word more successfully if the word begins with a single phoneme.

It would seem feasible that stimulus words involving sound-blends demand a more sophisticated form of phonological awareness, arguably true phonemic awareness, which, it has been claimed, may be facilitated by grapho-phonemic understanding or how letters map onto sounds (for example, Morais, Bertelson, Cary & Alegria, 1986). The mean score on the lower case letter-sound task in the study by Stuart and Coltheart (1988) was 4.6 (SD 6.3) which would seem to suggest the children in this sample would not have been able to employ an alphabetic strategy to identify the component sounds in a word beginning with a sound-blend.

As a result, the validity of employing alliteration tasks in the assessment of phonemic awareness has been questioned by Treiman (1991) who argues,

> Because some tasks that purport to measure phonemic awareness test only single initial consonants (i.e. one-phoneme onsets) and single final vowels (i.e. one-phoneme rimes), the tasks may actually measure awareness of onsets and rimes, not awareness of the phonemes that make up onsets and rimes. (p. 164)

It would seem that valid tests of phonemic ability may demand a more explicit awareness than the implicit or global sensitivity presumed by onset-rime awareness.

A recent test of alliteration, modelled on one of the earlier tasks (Bradley and Bryant, 1983), has however been described by Ellis and Cataldo (1990) as a test of <u>implicit</u> phonological awareness. Working with a sample of 40 children in reception classes, the authors administered a range of tests which also included measures of reading, spelling and letter-sound knowledge. From the results, some evidence was claimed for an association ($r = 0.36$, $p < .05$) between implicit phonological awareness (alliteration) and reading achievement during the first year in school. As some of the children in this study were reported to be already reading, it would seem probable that in this instance, they may have been able to make use of a rudimentary alphabetic strategy in the alliteration task. Arguably, the success achieved by application of explicit alphabetic knowledge in this task would seem to deny that phonological awareness at this stage could be described as purely 'implicit'.

Summary

In an attempt to understand phonological awareness and how it develops, this section has reviewed some of the many studies which have looked at this important component of phonological processing ability. The studies reviewed vary not only in the cognitive demands but also in the linguistic levels tapped by the tasks they have employed to assess phonological awareness. While Stuart's (1995a) claim for phonological awareness as ' ... an ability to decentre from the meanings of spoken words, and become aware that spoken words are also patterns of sounds' (p. 287) may provide a useful preliminary definition, results from several of the studies reviewed would seem to suggest that phonological awareness may not be a single homogenous skill. Furthermore, it seems likely that the constituent subskills of phonological awareness may make different contributions to the acquisition of literacy (Goswami & Bryant, 1990).

The next section discusses three contemporary models of reading to illustrate the possible role of phonological awareness at different stages in learning to read.

1.3 The Development of Reading

The relationship between phonological awareness and reading has been proposed in several studies yet there is still debate concerning the exact nature of this relationship. Two issues seem to recur in the literature: the first is whether phonological awareness plays a causal or consequential role in reading development and, closely linked to this, whether different levels of phonological awareness are related in different ways to reading development.

The development of reading has been the focus of extensive research which has served to highlight the complexity of the reading process. It would seem therefore that any evaluation of the links between phonological awareness and reading should make reference to the theoretical models which have informed the research.

In the last decade, two models of reading development have been prominent in the literature. Information processing models (for example, Morton & Paterson, 1980), developed from neuro-psychological studies of adult reading behaviour, are most often cited in studies of reading difficulties resulting from brain damage or acquired dyslexia (Patterson, Marshall & Coltheart, 1985). These models, while of great value in explaining how the 'normal' reading process may be adapted as a result of specific impairment to the brain, would however be inappropriately adopted in any study which wished to consider how that 'normal' reading process develops. Another influential paradigm, more evident in studies of normal reading acquisition, has been that of the developmental model. The developmental or 'stage' model acknowledges the dynamic nature of young children's reading development. As the name suggests, theories based on this model propose a series of stages through which a child is thought to pass before becoming literate. There are several versions of 'stage' theories of reading development. Three of the most influential models, to be discussed here, share some common features but the proposed differences may be of particular importance when attempting to identify precise stages of reading development.

1.3.1 Models of Reading Development: Marsh, Friedman, Welch & Desberg, 1981

One of the first of these models (Marsh, Friedman, Welch and Desberg , 1981) proposed four stages of reading development. During the initial 'linguistic substitution' stage, the child guesses at words, based on contextual meaning rather than by attending to any graphic features. For example, at this rudimentary stage, *puppy* may be substituted by *dog* . According to this theory, by the next, 'discrimination net substitution' stage, the child begins to recognise words via a visual similarity strategy. At this stage, unfamiliar words are often 'read' (or misread) as words with a similar visual pattern which already exist in the lexicon. Initially, Marsh and his colleagues argue, this similarity is limited to the first letter of the word so that the child may, for example, substitute *cats* when presented with *cime* in isolation, or *child* when *cime* is preceded by *the*. The third, 'sequential decoding' stage, is prompted by necessity as the child encounters ever-increasing quantities and varieties of printed text, and is no longer able to hold all the words encountered in a logographic lexicon. Marsh and his colleagues (1981) proposed that this stage is facilitated by a development in cognitive ability when the child becomes able to attend not only to the meaning of words but also to their constituent sounds (Piaget, 1963). As a result, the child acquires the ability to make accurate grapheme-phoneme associations, translating a series of printed shapes into a series of sounds. However, Marsh (1981) proposes such decoding is limited to regular words such as *dog* and *man*. At the final, 'hierarchical decoding' stage, the child is able to incorporate the rote learning and decoding acquired at the earlier stages with new conditional, higher order rules. For example, at this stage, the child can substitute the sound / S / when the letter *c* is followed by *e, i* or *y* as in 'ice cream'. This stage is also marked by the use of analogy, where, for example, the child who can read *tough* is able by extension to read *rough* and then *enough*. This strategy however, according to Marsh and Desberg (1983) may be

> ... available early in the stage of concrete operation, (but) it is not used spontaneously to any great extent until much later in development. (p. 152)

The abstract reasoning which may be said to underpin this use of analogy, it has been claimed, is not fully mastered until the child is approximately ten years old and has reached the concrete operational stage of cognitive development (Piaget & Inhelder, 1958).

A number of research findings have supported this theory that some form of logographic strategy is employed in the early stages of reading development (for example, Ehri, 1980; Reitsma, 1983). However, these studies also suggest that this may not be to the exclusion of phonological influence. Marsh et al.'s (1981) proposal that inability to hold an ever-increasing sight vocabulary in memory prompts the transition between the 'discrimination net' and 'sequential decoding' stages has been challenged by studies which report that phonic skills are necessary antecedents of improved word recognition (Davies & Williams, 1974).

In support of this, another study (Stuart & Coltheart, 1988) contests the rigidity of the stage model, arguing that not all children pass through the same sequence of stages. Results from this later study proposed that phonologically adept children utilise their phonological skill from the earliest stages of reading and that an absolute logographic strategy is adopted only by those who lack such skill. More recently, two other studies (Goswami & Mead, 1992; Muter et al., 1994) have suggested that children as young as six years of age are able to use analogies in reading when they are trained in phonological awareness at the sub-syllabic, onset/rime, level. In the light of more recent research (for example, Treiman, 1985), the early theory by Marsh and his colleagues would seem limited by its focus on grapheme-phoneme associations with no acknowledgement of the child's early syllabic or intra-syllabic, onset/rime, sensitivity.

However, this theory (Marsh et al., 1981) would seem important for its discrimination between two stages of logographic reading: the first in which a purely context-bound strategy is available and the second where early phonemic cues may enable the child to read some words out of context, as demanded by single-word reading tests.

1.3.2 Models of Reading Development: Frith, 1985

Frith revised the earlier account (Marsh et al., 1981) to produce her three-stage model of reading. In the first phase of this model, the 'logographic' stage, word recognition is based only on salient visual clues; the child has no phonological strategy available and is unable to recognise unfamiliar words presented in isolation; for example, 'camel' is readily identified by the 'two humps in the middle' (Gough, Juel & Roper-Schneider, 1983). Frith's 'logographic phase' would therefore seem to fit between the first and second stages of the earlier model.

Frith (1985) suggested that at the next, 'alphabetic' stage, children are 'decoding grapheme by grapheme' (p. 306). Frith suggested that this stage closely paralleled the 'sequential decoding' phase proposed by the earlier study (Marsh et al., 1981). However at Marsh's 'sequential decoding' stage a child is thought to decode only letter-by-letter and reading is therefore limited to regular CVC (consonant-vowel-consonant) words with short vowels (for example *dog* or *man*). However, the grapheme-phoneme correspondence, evident in Frith's 'alphabetic' stage, enables the child to decode irregular or more complex words. For example, using letter-sound correspondence, the word *house* translates into five sounds, **h/o/u/s/e**; using grapheme-sound correspondence it becomes only three sounds, **h/au/s**. A child at Frith's 'alphabetic' stage would seem to have a greater chance of successfully decoding *house* than the child at Marsh and his colleagues' 'sequential decoding' stage. This would seem to suggest that 'sequential decoding' may be an interim step prior to the acquisition of a fully alphabetic strategy in reading development.

According to Frith (1985), in the final, 'orthographic' stage, the child moves from grapheme by grapheme translation to translate sequences of letters 'into orthographic units without phonological conversion' (1985, p. 307). Ideally, she reports, these orthographic units are also morphemic units, for example the 'run' and 'ing' in 'running'. Frith's theory would seem to suggest that reading at this stage utilises the visual strategy developed earlier, yet disregards the subsequent phonological strategy: no explanation for this strategic discrimination is offered by Frith. Frith's (1985) claims for parity between her 'orthographic stage' and the 'hierarchical decoding' stage in the first model (Marsh et al., 1981) are difficult to accommodate if there is, as she states, 'no phonological conversion' (p. 307). It could be argued, however, that orthographic units such as *ing* also represent a series of sounds and that recognition of these letter strings may not exclude the use of a phonological strategy.

As in the previous model, Frith (1985) does not acknowledge the importance of syllabic and subsyllabic units to reading development.

1.3.3 Models of Reading Development: Ehri, 1995

The first of the four stages proposed by Ehri (1995) is the 'pre-alphabetic' phase. This stage bears some resemblance to Frith's (1985) first stage, where the child uses a visual clue strategy to recognise words. At this stage, Ehri claims, the child focuses on both context and visual patterning of the whole word so that individual letter changes go undetected. Support for this came from a study in which 96 children (age range 3 years to 5 years) were asked to match the word *Pepsi*. Presented with the same type-face and ink colour, most of the children (75%) failed to notice that *Pepsi* had been changed to *Xepsi* (Masonheimer, Drum & Ehri, 1984). Similarly, as no association is made between letters and sounds, children have been found to connect print to ideas, resulting in words which are equivalent at the semantic rather than the phonemic level; for example, reading *toothpaste* for *CREST* (Goodman & Altwerger, 1981). Ehri (1991) suggests that 'logographic readers do not remember letters in words (because) they have not mastered letter names or sounds' (p. 389). It could be argued that few children could associate letter names to graphemes without formal instruction and Ehri's statement would seem therefore to infer the need for 'instruction' between the first and second stages.

By the second or 'partial alphabetic' stage, the child has acquired some letter-sound knowledge and can employ some, though not all, grapheme-phoneme associations. First and final letters are reported to be particularly salient and, as only minimal visual-verbal clues are used at this stage, it is thought confusion may arise when words share similar orthographic or phonological patterns, for example the word *man* may be read as *men*. Children reading at the 'partial alphabetic stage' are more able to read words which contain salient clues linking letters to sounds, for example, reading *elephant* from 'LFT', than words which have no such association, for example, reading *elephant* from 'WcB' (Ehri & Wilce, 1985). Data from the same study indicates it is at this stage that children begin to read a measurable number of words. Studies by Byrne and Fielding-Barnsley (1989; 1990) propose that this transition between the 'pre-alphabetic' and 'partial alphabetic' stages is dependent on the acquisition of both alphabetic knowledge and some phonemic awareness.

The next stage proposed by Ehri, the 'full alphabetic ' stage, occurs when the child combines phonological decoding and sight word reading. Although an initial decoding strategy is thought to underpin this stage, once the word has been decoded and has been practised sufficiently, it is stored as a unified whole rather than as a string of individual phonemes. At this stage, Ehri claims, readers store and read 'exceptional' words by sight. 'Exceptional' words in this instance include those containing silent letters, for example, *island*, *listen* and *talk* (Ehri & Wilce, 1985).

In the final, 'consolidated alphabetic' phase, Ehri (1995) claims 'letter patterns that recur across different words become consolidated' (p. 121). This would seem to link closely with the use of analogy documented by Marsh and his colleagues' (1981) 'hierarchical decoding' and Frith's (1985) 'orthographic' stages.

There are both similarities in and discrepancies between the three models described here. Fig. 3 combines the three models to suggest one way in which they may complement each other. Each may be useful in identifying specific stages in reading development and how such stages may be associated with early phonological awareness.

Fig. 3 Summary of Stage Models (Marsh et al., 1981; Frith, 1985 and Ehri, 1995)

Marsh et al., (1981)		Frith (1985)		Ehri (1995)	
linguistic substitution	*rote association based on context*				
		logographic	*visual clues, based solely on context*	**pre-alphabetic**	*salient visual clues*
discrimination net substitution	*visual similarity, early letter-sound links, in isolation*				
				partial alphabetic	*letter sound/name knowledge required, partial grapheme-phoneme association, regular words/non-words only*
		alphabetic	*grapheme-phoneme association, regular/irregular words*		
				full alphabetic	*use of some higher order rules, full grapheme-phoneme association, sound blending*
hierarchical decoding	*use of higher order rules, rote learning, decoding, analogy*	**orthographic**	*non-phonological, recognition of orthographic /morphemic units*	**consolidated alphabetic**	*use of larger units to expedite sight word learning*

Summary

In an attempt to identify underlying cognitive processes which may prompt changes in normal reading development, these stage models appear to have made a significant contribution to a clearer understanding of possible causes for reading difficulties. However, by their prescriptive nature they tend to suggest that reading development follows a universal pattern for all children. Some studies (for example, Stuart and Coltheart, 1988) contest the rigidity of the stage model, arguing that children who are phonologically skilled before learning to read might use these phonological skills from the outset. Children who lack such skills may, however, be dependent solely on the visual strategy associated with the logographic stage.

At the same time, other studies have focused on the 'instructional process' (Byrne, 1992, p. 31) in explaining developmental models and success or failure in reading acquisition.

1.4 Reading Acquisition, Instruction and Assessment

Unlike oral language, reading is not a natural skill but is culturally transmitted. From an education perspective, this 'cultural transmission' is most readily identified by the form of reading instruction employed. Tunmer and Rohl (1991) claim that a lack of clear discrimination between reading instruction and reading acquisition has added further to the complexity of understanding the precise relationship between phonological awareness and reading development,

> The claim that phonological awareness is necessary for learning to read an alphabetic orthography does not imply that children need to become phonologically aware before they begin reading instruction. Here it is essential to distinguish between reading instruction and reading acquisition. The former has to do with what we do to children to facilitate the acquisition of reading skills,

> the latter has to do with what goes on inside children's heads as they learn to read. (p. 16)

Studies from which stage models of reading acquisition have arisen give no details of the styles of reading instruction which may have been employed.

1.4.1. Studies of Reading Instruction: Alegria, Pignot and Morais, 1982

A few studies have, however, investigated the influence of reading instruction on phonological awareness and reading attainment. Evidence from an early study (Alegria, Pignot & Morais, 1982) in which two groups of six year old children received either whole-word or phonic-based instruction, suggests that phonological awareness developed faster in the group who received the phonics training. Phonological awareness was assessed in this study by two 'reversal' tasks. In the first, the children had to reverse the phonemes in a word (for example, given *os*, the correct response would be *so*) and in the second, the order of two syllables was reversed (for example, given *butter*, the correct response would be *terbut*). Children instructed by the phonics method performed significantly better on the phoneme reversal task, leading the authors to conclude that the logographic or whole-word approach does not enhance phonological ability. However, the results of this study should be interpreted carefully as no measure of reading was taken. It is, therefore, possible that the 'phonics' group may have been better readers and that 'spinoff' skills of reading, such as the ability to maintain phonological codes in working memory or create orthographic images, may have contributed to their success in the reversal, and particularly the phoneme reversal, tasks.

1.4.2 Studies of Reading Instruction: Seymour and Elder, 1986

Seymour and Elder (1986) looked more specifically at the influence of instruction on reading development. Results from their study of beginning readers support the earlier findings that phonological awareness does not develop with whole-word reading instruction. The speed with which the children identified words, regardless of length, was taken as evidence that word recognition was based solely on identification of logograms or whole visual patterns. Further analysis of the errors in this study, suggested that semantic substitutions were more common than phonological substitutions, for example *white* was read as *green*, *boat* was read as *yacht*, whereas *of* was not read as *off*. Seymour and Elder (1986) concluded that this dependence on visual clues, rather than characteristic of an initial logographic stage of reading (Frith, 1985) may have been simply an artefact of reading instruction. However, as the study did not include a 'control' group receiving the more usual combined whole-word and letter-sound reading instruction (Stuart, 1995a), it could be argued that dependence on a visual strategy is not exclusive to children trained in whole-word recognition.

The association between phonological ability and reading achievement may be influenced by the method of reading instruction. In line with this, it could be argued that the strength of the proposed association may depend on the task employed to measure reading. The literature reveals a marked inconsistency in the way in which reading itself has been assessed.

1.4.3 Assessment of Reading

The earlier part of this review has suggested that clear understanding of the relationship between phonological awareness and reading development has been confounded in part by the multitude of ways in which phonological awareness has been assessed. It could also be argued that comparison between studies has been further impeded by the equally disparate range of reading tests which have been employed.

In the case of standardised reading tests, there is some evidence of parity in performance between the various tests. However, on close examination, it would seem that despite standardisation, different tests may actually focus on different subskills of reading ability. At the same time, tests of nonword reading commonly appear in the literature on the development of phonological awareness and reading: none of these to date offers details of standardisation.

Typically, studies of the relationship between phonological awareness and literacy have employed only one measure of reading ability. Three standardised tests are reported in a number of these studies.

BAS Reading Test (Elliott et al., 1983)

This reading measure from the British Abilities Scales (Elliott et al., 1983) is a context-free graded list of 90 words commonly used in psychometric assessment. From a research perspective, it has typically been included in correlational studies which investigate the relationship between early cognitive measures (for example phonological awareness or phonological memory) and subsequent reading ability (for example, Stuart 1990; Gathercole, Willis & Baddeley, 1991). The performance of young children on this measure is generally poor: in Stuart's study (1990) none of the four year old children in the sample could read one word; in Gathercole, Willis and Baddeley's sample of four year old children, 54 out of a total of 57 children also failed to read any of the target words. Ironically, the single-word reading test has often been cited as a preliminary procedure to eliminate those children who can read in studies where a preliterate or nonreading sample is required (for example, Muter et al., 1994).

Neale Analysis of Reading Ability (Neale, 1989)

This test also has been used in a number of studies with young children (for example, Hatcher, Hulme & Ellis, 1994; Muter et al., 1994). The test, which comprises a series of graded passages accompanied by picture cues, has been used as both a measure of reading accuracy and of reading comprehension. Scores on the test were low in a study of seven year old children who were experiencing literacy difficulties (Hatcher et al., 1994). Another study of younger, four year old children reported scores which were positively skewed and indicative of floor effects (Muter et al., 1994).

Primary Reading Test (France, 1981)

This test is a graded multiple-choice test of 48 questions. In the first 16 questions, the child has to name a picture and then choose the corresponding word from an adjacent list. From the literature, performance on this task would seem to be better than on the other two reading tasks. One study of six year olds (mean age 6 years 7 months) recorded a mean reading age of 7 years 6 months on this task (Bryant et al., 1990). Similarly, when only the first 16 trials were given, significantly better results (max = 16; mean 4.34; SD 3.38) were also recorded for the group of four year old children who had been unable to read on the BAS measure (Gathercole et al., 1991).

Studies which focus particularly on the influence of phonological recoding as children learn to read often include a test of nonword reading. Nonwords can be classified as regular, for example, *hap* or *twud;* or irregular, for example *aund* or *hausage.*

Nonword Reading Tests

The rationale for this type of reading assessment is straightforward: as nonwords have no lexical cue in long term memory, they can only be successfully read by employing the full grapheme-phoneme association and sound blending cited in Ehri's (1995) 'full alphabetic' stage of development. Several measures of nonword reading appear in the literature but cross-study comparison is often impossible because of variety within the task stimuli and the apparent lack of standardisation procedures. One longitudinal study which investigated the relationship between pre-reading phonological skill and literacy attainment six years later (Stuart & Masterson, 1992), took measures from two tests of nonword reading. In the first, a test used previously by Snowling, Stackhouse and Rack (1986), the child was asked to read a set of 31 nonwords which had been created by changing one letter of an irregularly spelled real word, for example, *kiscuit* from *biscuit*, *duede* from *suede*. The second test, devised by Stuart and Masterson (1992), measured reading ability on a list of 80 regular nonwords which varied in syllable length and complexity. These nonwords were constructed by manipulating syllable length and consonant clusters, for example, *hap, twud, radun, brafeld*. For the analysis of the results, the children were assigned to one of two groups based on their pre-school phonological ability.

Stuart and Masterson (1992) considered the nonwords in the first test (Snowling et al., 1986) to be more 'wordlike' than the regularly spelled nonwords in the second test; they therefore predicted that the first test would result in more errors based on lexical similarity. Their prediction was largely borne out by the results: the degree of lexical similarity between the nonwords affected the way in which the children read them. In the first test, the majority of the errors made by both groups of children, those with good pre-reading phonological skill and those with poor pre-reading phonological skill, were lexicalization errors. In the second test, however, the children who had good phonological skill at the pre-reading stage, made significantly more phonologically based reading errors. This prompted Stuart and Masterson (1992) to suggest that children with good phonological awareness may be better able to use a sublexical route for reading.

Treiman, Goswami and Bruck (1990) have suggested that children adopt different strategies for reading different types of nonword. Their study demonstrated that children use a form of rime-analogy to read consonant-vowel-consonant nonwords which have 'regular' rimes, thus making errors such as reading *kear* (which rhymes with *ear*) as /k**/ by using a rime pronunciation which is correct for the ** rime in *bear*. For nonwords with less common rimes, however, it is claimed, they use a more direct grapheme-phoneme strategy, for example reading *jough* as *jog*, It would seem therefore that the corpus of nonwords used in nonword reading tasks may influence the strategies children adopt to complete the tasks.

For one recent study of the development of phonemic strategies in spelling and reading, a series of nonword reading and spelling tests was designed and piloted over a period of two years (Huxford, 1993). The children in this study were assessed during their first year of formal schooling. At the design stage, therefore, close attention was given to the predicted limited alphabetic knowledge of very young children and the phonetic structure of the nonwords. As beginning readers are often reported to 'read' unknown words by identifying the visual patterning in words (Treiman et al., 1990), any nonwords which could be read using a purely lexical or visual strategy were eliminated. The final list contained nonwords of consonant-vowel, vowel-consonant or consonant-vowel-consonant construction and this list was used to assess both reading and spelling ability.

The use of only nonwords for the assessment of reading ability has been previously criticised. The ability to read nonwords, Goswami and Bryant (1990) protest, '... does not mean that [these] children necessarily read real words in the same way' (p. 46).

Summary

This section has considered the considerable influence of instruction on reading development. Although the 'developmental nature' of phonological awareness has been acknowledged by a number of studies (for example, Goswami & Bryant, 1990; Muter et al., 1994), few have taken account of the effect of particular forms of reading instruction. Similarly, few studies have assessed the relationship between phonological awareness and performance on a range of reading tests which may be indicative of the specific reading strategies a child has available.

Byrne (1992) suggests that the 'logographic' stage with its dependence on a visual strategy, where the child builds a non-analytic association between the spoken word and a sequence of print, should be regarded as 'the default acquisition procedure for reading' (p. 14). This stage can, however, be circumvented, Byrne suggests, if the child has access to a mental representation of speech at the level of the phoneme and knows how letters symbolise phonemes. A number of studies which focused on phonological awareness at the level of the phoneme have been reviewed earlier in this chapter; the next section considers the importance of alphabetic knowledge to reading acquisition.

1.5 Knowledge of the Alphabet

Despite their differences, the models of reading development discussed earlier all propose a strategic point when it becomes necessary for the novice reader to transfer from using a purely visual strategy to one which is dependent on alphabetic knowledge. There is now evidence from several studies of a significant association between alphabetic knowledge and reading development (for example, Ellis & Large, 1988; Hoover & Gough, 1990; Tunmer & Nesdale, 1985). Whilst this association between letter knowledge and reading in an alphabetic orthography may seem unsurprising, there is convergent evidence that alphabet knowledge in isolation does not account for success in early literacy (for example, Byrne & Fielding-Barnsley, 1989).

Alphabetic knowledge, it has been reported, encompasses at least two different skills. The first is to attribute letter names to the appropriate ciphers, which is, arguably, a paired-associate learning ability. The second is to make the specific association between the written cipher (the grapheme) and the sound it represents (the phoneme). This is generally defined as 'grapho-phoneme correspondence'.

As with the theories reviewed earlier on the nature of phonological awareness and its part in the reading process, opinion is also divided on the role of alphabetic knowledge in reading development. This debate would appear to centre on whether letter knowledge precedes and precipitates phonological awareness or, alternatively, whether inert phonological awareness is 'activated' by the acquisition of alphabetic understanding. According to the first line of argument, knowledge of letter sounds influences reading development by facilitating the ability to segment words into their constituent phonemes (Hohn & Ehri, 1983). Stuart and Coltheart's (1988) study, on the other hand, posed a different interpretation of this integral link between alphabetic knowledge and phonological awareness. They suggest,

> ... for children to bring their phonological analysis to bear upon reading, they must also have understood how speech sounds are represented by printed letters.
> (p. 162)

There is little evidence in the literature of assessment of alphabetic knowledge <u>and</u> measures of phonological awareness in children before they begin to read. However, there are several studies which do report the association between knowledge of letter names or sounds and reading some two years after school entry (for example, Blatchford, Burke, Farquhar, Plewis & Tizard, 1987; Share, Jorm, Maclean & Mathews, 1984).

In one large study of 543 five year olds (Share et. al., 1984), letter-sound knowledge was found to correlate significantly with reading development over the ensuing three years. However, as no measure of reading ability was taken at the outset, it could be argued that some of these children were already reading before the study began. The good readers reported may therefore simply have been beneficiaries of the 'Matthew effect'. This theory, based on the Biblical analogy where the rich are observed to become richer, and the poor to become poorer, proposes that the more a child reads, the better his or her reading will become (Stanovich, 1986).

The later longitudinal study by Blatchford and his colleagues (1987), would seem to confirm the importance of alphabetic knowledge to reading development. Results from a broad range of assessment tasks administered to a large sample (n = 343) of nursery-age children, found pre-school letter identification to be the task which correlated most significantly with subsequent reading.

Despite some claims that alphabetic knowledge may be predictive of subsequent reading (Bradley & Bryant, 1985), cross-study comparisons and assessment of the interaction between alphabet knowledge, phonological awareness and reading development are again impeded by the diversity of tasks and methodologies evident in the literature.

1.5.1. Letter Sounds and Letter Names

There appears to be no consensus as to whether letter-name knowledge is more important to reading development than letter-sound knowledge. While evidence from early studies proposed an association between knowledge of letter-names and reading ability (Bond & Dykstra, 1967; Chall , 1967), it has also been suggested that knowledge of letter sounds, rather than letter names, aids early reading and spelling ability (Clay, 1991). The observed association between letter-names and reading development however may be readily explained as, it has been noted, most consonantal sounds are, in fact, articulated in the letter name, for example the /f/ in 'ef' (F) or the /s/ in 'es' (S) (Treiman, 1993).

In general, studies which assess alphabetic knowledge have neither discriminated between, nor made qualitative evaluation of, the child's knowledge of letter names in preference to letter sounds or vice versa. In some studies the child has been given the option to either name or give the sound of the stimulus letter and either has been accepted as a correct response (Blatchford et. al., 1987). In other studies, letter-name and letter-sound knowledge have been assessed but the scores from the two tasks have then been amalgamated (Tunmer, Herriman & Nesdale, 1988).

In one large study (Tunmer et al., 1988) of first-grade children (mean age 5 years 8 months), phonological awareness measures were found to account for 23% of the variance in a nonword reading test. The amalgamated scores of letter-name and letter-sound knowledge accounted for a further 16% of variance. In a further analysis, when measures of phonological awareness were combined with the alphabetic scores, they accounted for another 4% of variance in reading ability. The task required the children to give either the letter name or the letter sound and no further analysis was undertaken to examine any relationship between the two types of alphabetic skill or their independent influence on subsequent reading .

Following a previous study (Blatchford et al., 1987), which reported a correlation between pre-school letter identification and reading attainment two years later, Blatchford and Plewis (1990) set out to investigate the specific association between aspects of alphabetic knowledge (sounds **or** names) and subsequent reading. In this study, all 26 letters of the alphabet were presented on 5 cards; no information is given whether letters were randomly or selectively allocated to individual cards. The child was asked "Do you know what letter this is?" (1990, p. 426). Based on whether the child responded with the name or the sound, the experimenter then asked for the alternative, name or sound. Mean scores for both naming and sounding were low (mean score = 5) and the high standard deviations at the pre-school stage would seem to suggest scores were bi-modally distributed. It was also reported that children were more likely to know letter names than letter sounds. By the end of the reception year the children were found to know twice as many names (mean score = 12) as sounds of letters (mean score = 6) but there was a significant correlation between letter-naming and letter-sounding knowledge. When scores from a subsequent reading test were analysed, the association with letter-naming was found to be stronger ($r = 0.70$, $p <.001$) than with letter-sounding ($r = 0.59$, $p <.05$). Evidence of the limited increase in knowledge of letter-sounds in this study suggests that little phonological instruction took place in the first year of formal schooling.

Other studies have emphasised the importance of reading instruction to the reading acquisition process (for example, Seymour & Elder, 1986). There is no reference to the type of reading instruction experienced by the children in this study but this would seem to be an important consideration in any study investigating the development of alphabetic knowledge.

An earlier study (Stuart, 1987) assessed letter-sound and letter-name knowledge by showing a group of children (n = 23) random sequences of letters printed singly on cards. For the first task, the children were required to give the letter name and, for the second task, the letter sound. The scores were noted to be bi-modally distributed, but significant correlations were reported between pre-school phonological skills and the two forms of alphabetic knowledge which were tested after one term in school. Whilst no association was found between pre-school phonological awareness and early reading, a significant relationship ($r = 0.56$, $p < .01$) was found with reading when the pre-school phonological awareness scores were combined with the letter-sound scores. A significant association was also found between letter name and letter sound knowledge but, interestingly, this association was no longer significant when the pre-school phonological scores were held constant. As no pre-school measure of letter knowledge was taken, the relationship between all three variables, pre-school alphabetic knowledge, pre-school phonological awareness and subsequent reading was not investigated. Based on the results of this study, a 'modified' model for reading was proposed where

> ... children will use whatever skills they have available from the very first as they learn to read. [Findings from this study] ... also support the view that phonological skills and knowledge are useful to beginning readers and can be used by them from the beginning. Children without such

> knowledge ... will have no option but to become logographic readers. (Stuart & Coltheart, 1988, p. 164)

Further assessment of phonological awareness and letter-sound knowledge prior to formal schooling may determine whether use of phonological skills in the early stages of reading is facilitated by alphabetic knowledge.

In line with Stuart and Coltheart's (1988) proposal, Ehri and her colleagues (1995) suggest that once the grapho-phoneme concept is grasped, children begin to make and store these crucial associations between printed words and their pronunciation, retrieving the appropriate pronunciation each time the original printed word is encountered. Thus even at the earliest, logographic stage, they suggest, the child may be employing some rudimentary aspect of grapheme-phoneme correspondence. Ehri further contends that the most mature stage of word recognition, the 'orthographic' phase of Frith's (1985) model, is at root dependent on a combination of alphabetic and phonological strategies.

1.5.2 Modality of Presentation

As discussed earlier, clear understanding of phonological awareness has in part been impeded by the lack of consistency between studies. The same may be said of studies of alphabetic knowledge which target different skills and employ diverse methodologies. Some studies have made a specific demand for either letter names or sounds (Stuart & Coltheart, 1988); some have accepted either letter names or letter sounds as chosen by the child (Tunmer et al., 1988) some have presented letters randomly (Stuart & Coltheart, 1988); some have displayed the letters in a pre-selected order (Blatchford & Plewis, 1990); some have presented letters on single cards (Stuart & Coltheart, 1988) while others have used separate cards with an array of letters on each card, most commonly arranged in groups of five (Blatchford et. al., 1987; Blatchford & Plewis, 1990).

However, one aspect in which there does seem to have been some consistency is that of modality of presentation. In the main, most of the studies cited have displayed a written cipher (grapheme) and asked the child to identify the name and/or associated sound. Grapho-phoneme correspondence, or this encoding from visual cipher to sound, has been well documented as a necessary component skill of reading (Adams, 1990; Ehri, 1995). A growing number of studies has also highlighted the use of a phonological strategy in spelling (Bryant & Bradley, 1980; Frith, 1980; Snowling & Perin, 1983). In spelling, the primary skill is phoneme-grapheme conversion, where a sound has to be recoded into a written cipher or group of ciphers.

One study investigated the development of the component phonological strategies of reading and spelling by employing assessment of letter knowledge in different modalities (Huxford, 1993). In the 'aural-stimulus' condition, children were shown a group of letters and had to locate the letter whose name or sound was spoken by the experimenter. In the 'visual stimulus' condition children were shown single letters and asked to articulate either the appropriate name or sound. In contrast with the Blatchford and Plewis study (1990), results from this study revealed that throughout this longitudinal project, children's knowledge of letter sounds exceeded their knowledge of letter names. At the same time, scores from the 'aural-stimulus' condition were so much higher than those from the 'visual-stimulus' condition that the experimenter 'doubted that some children fully understood the (visual-stimulus) task despite careful re-phrasing of the requests and use of examples' (Huxford, 1993, p. 190). In consequence, Huxford (1993) recommends that conclusions about letter knowledge from this study should be handled with some reservation.

1.5.3 Order of Acquisition

Although several studies have included tests of letter sound or letter name knowledge, few give details of the construction of the tests in terms of the order of presentation of the letters.

The results of one study (Stuart & Coltheart, 1988), proposed a hierarchical order for learning letter sounds, based on consonantal strength. This, the authors suggested, was consistent with the theory that children's learning of letter-sounds

> ..... is influenced by the state of the child's internal phonological system. This argument implies that children need to be aware of particular phonemes before they can learn to assign the phonemic property to the letter which correctly represents it. (p. 159).

As no measure of pre-school alphabetic knowledge was taken it was not possible to determine whether there was any significant relationship between phonological awareness and the learning of letter-sounds prior to the onset of reading instruction.

Correlations between the order of acquisition proposed in this study and in the later longitudinal study by Huxford (1993) were statistically significant (ranging from $r = 0.56$, $p < .01$ to $r = 0.73$, $p < .001$ across the four assessment points). The ranked list proposed by the two studies is shown in Appendix A.

1.5.4 The 'Alphabetic Principle'

Despite some suggestion of a predictive quality, there is still some uncertainty whether letter knowledge is causally related to reading development. In an attempt to clarify the nature of the relationship between alphabetic knowledge and reading, Byrne and Fielding-Barnsley (1989) propose that 'the alphabetic principle lies between knowledge of letter sounds and reading ability' (p. 313). The alphabetic principle itself they define as, a 'usable knowledge of the fact that phonemes can be represented by letters, such that whenever a particular phoneme occurs in a word, and whatever position, it can be represented by the same letter' (p. 313). To apply this principle appropriately, Byrne and Fielding-Barnsley suggest, it is necessary for the child to have mastered three 'insights'. First, the beginning reader must understand that words can be broken into individual sounds (phonemes). Second, he or she must realise that these sounds and patterns of sound recur in different words and, finally, the child must to able to make the association between these sounds and the letters (graphemes) which consistently represent them. Byrne and Fielding-Barnsley (1989) conclude the first two skills are phonemic skills and the final is an alphabetic skill.

A further study, (Byrne & Fielding Barnsley, 1990) confirms that training in alphabetic awareness alone does not enhance reading development. However, this study included no assessment of the children's phonological awareness before the intervention programme, and it is therefore possible that the children for whom the intervention programme was unsuccessful, that is those who received only training in alphabetic skill, also lacked phonological ability.

1.5.5 Writing in an Alphabetic Code

It has been suggested that writing is a 'mirror image' of reading (Riley, 1994, p. 41) and that true understanding of literacy develops through exposure to the two activities (Durkin, 1966; Chomsky, 1971). Few studies appear to consider writing ability, but two large scale projects have included a measurement of written language ability as part of a much larger test battery. Results from the first, a longitudinal study (Tizard, Blatchford, Burke, Farquhar & Plewis, 1988) of 343 children who were monitored from nursery, indicate a significant correlation ($r = .61$, $p < .001$) between the child's ability to write his/her own name on school entry and reading two years later.

A similar correlation ($r = .57$, $p < .001$) between this type of pre-school writing ability assessment of name-writing and reading one year later was proposed in a longitudinal study by Riley (1994). Results from this study of 200 children are however obscured by the complex marking structure for the task. If the child was able to write both first and second name, he/she was awarded 10 points.

However, if the child was unable to write independently, the experimenter wrote for the child and he/she was awarded a maximum of 5 points. No discrimination is made in the results between the child who scored 5 points because he/she could only dictate the letters and the child who scored 5 points because he/she could form at least some letters without assistance. It could be argued that the first child, although unable to write letters, was 'phonologically aware' and could identify the individual sounds in his/her name. The second child, although able to write half the letters in his/her name, may have been 'phonologically unaware' but had simply learned to copy meaningless ciphers by rote.

This association between letter knowledge and phonological awareness is, Tunmer and Hoover (1992) propose, an important one

> letter-name knowledge should help beginning readers discover grapheme-phoneme correspondences because the names of most letters contain the phoneme to which the letter normally refers. However, letter-name knowledge may interact with phonemic-segmentation skill such that only children who can segment letter names, such as /bi/,/ɛf/, /ʝ́e/ and /ɛl/, will benefit from letter-name knowledge. (p. 194)

Summary

The studies reviewed above suggest that alphabetic knowledge and writing ability may be predictive of subsequent literacy achievement. They also propose that it is the catalytic relationship between phonological awareness and alphabetic knowledge which influences reading development.

Despite some evidence that phonological awareness precedes and, arguably, predicts subsequent reading ability (for example, Bradley & Bryant, 1978; Liberman et al., 1974; Treiman & Zukowski, 1991), Morais (1991a) contends that it is alphabetic literacy which prompts phonological awareness at the phonemic level. The next section considers this 'causal/consequential' debate which has permeated investigations of the association between phonological awareness and the acquisition of reading.

1.6 Phonological Awareness and Reading

Claims for a causal link between phonological awareness and reading have come from a range of correlational and longitudinal studies (for example, Bradley & Bryant, 1983, 1985; Lundberg, Oloffson & Wall, 1980; Stanovich, et al., 1984; Stuart & Coltheart, 1988). Such claims have however been challenged by other, often cross-linguistic, studies which propose that phonological awareness arises as a consequence of reading in alphabetic script (Morais et al., 1987).

1.6.1 The Causal/Consequence Debate

The longitudinal design, evident in many studies, seeks to identify relationships between selected variables measured across several points in time. Whilst the resulting correlational data can demonstrate the existence of a relationship, correlations cannot however be taken as evidence of causality. Goswami and Bryant (1990) suggest that any proposed correlation may be spurious if the study does not control for other variables such as IQ. It has often been claimed in the literature, that data from training studies can demonstrate a more reliable cause-effect relationship between early phonological awareness and subsequent literacy success. This section considers the supporting yet conflicting evidence from training and cross-linguistic studies.

1.6.2 Training Studies

The lack of consistency between longitudinal studies of phonological awareness has been discussed earlier; the methodologies, sample sizes, age ranges and length of interventions detailed in training studies would appear to be equally disparate.

The longitudinal study by Bradley and Bryant (1983; 1985), described previously, proposed a significant association between the ability of young preliterate children to categorise rhyming and alliterative sounds and their subsequent reading achievement. While correlational evidence such as this may indicate a genuine relationship, it does not necessarily reflect a causal influence: the positive association between the two skills could have been affected or determined by another unknown factor. For this reason, Bradley and Bryant included a 'properly controlled training study [to] demonstrate cause-effect relationships.' (Bradley, 1989, p. 8).

In this training study (Bradley & Bryant, 1985), 65 six year old children, who had performed poorly on the sound categorisation tasks in the earlier longitudinal study (Bradley & Bryant, 1983), were assigned to four groups matched for age, sex and IQ. The three experimental groups received specific training in a one-to-one tutorial style over a two year period. The first group received training in sound categorisation, the second in sound categorisation plus letter-sound correspondence and the third in semantic categorisation. A fourth control group received no training. Following the intervention programme, the highest reading scores were reported for the group who had received instruction in both sound categorisation and letter-sound correspondence. Although differences between reading scores for the other two experimental groups failed to reach significance, the authors (Bradley & Bryant, 1985) report the results from this study to be 'the first adequate empirical evidence that the link (between phonological awareness and reading) is causal.' (p. 421). It could be argued that as the group sizes in this study were so small (n = 13) and the sound categorisation only group showed little advantage in reading ability over the semantically trained group, there would seem insufficient evidence to substantiate the authors' rather firm claim for causality. However, this study signalled an important step in the understanding of phonological awareness as it was one of the first to demonstrate the benefits of integrating phonological awareness training with letter-sound instruction.

A predictive relationship between alphabetic knowledge and reading development has been cited in several studies (for example, Ellis & Large, 1988; Tunmer et al., 1988); as no group in the study by Bradley and Bryant (1985) was trained only in letter-sound knowledge, it is possible that the observed higher reading scores resulted from the alphabetic training itself rather than from the combination of sound categorisation and letter-sound knowledge. The study failed to determine whether alphabetic training, in and of itself, would positively affect reading ability. To investigate this, Ball and Blachman (1988) conducted a seven week intervention study of 89 kindergarten children who were each assigned to one of three groups.

As in the earlier study (Bradley & Bryant, 1985), one group was trained in sound categorisation and letter-sound correspondence while another group was trained with general 'language activities' such as listening to stories, together with letter-sound instruction. The third group received no training. Results from the study suggest that increasing letter-sound knowledge in the absence of sound categorisation training did not result in greater achievement in reading, but there is some support for Bradley and Bryant's (1985) finding that combined training in phonological awareness and alphabetic knowledge made a positive impact on reading development. However, as the Ball and Blachman (1988) study failed to assess other post-intervention skills, such as mathematical ability, it could be argued that the observed improvement could reflect the positive response of these very young children to small group activities with a 'novel' teacher.

Similar conclusions regarding the benefits of 'combined' training programmes arose from a twenty week study of poor, rather than beginning, readers (Hatcher et al., 1994). In this large, cross-county intervention programme, 125 six and seven year old children with reading quotients below 86 (Carver, 1970) were assigned to one of three experimental groups or a control group. Children in the experimental groups were trained individually in reading and phonology, reading alone, or phonology alone while the control group received only regular classroom teaching. Results from a range of post-intervention tests which included assessments of single word reading, nonword reading, comprehension and mathematics, confirmed that forming explicit links between phonological awareness and letter identification was a powerful way of enhancing children's reading. At the same time, the differential improvements observed across the groups were not found to be a consequence of a more general improvement in overall performance.

These training studies provide convincing evidence that phonological awareness and alphabetic knowledge together play an important role in the development of reading. However, results from the third study (Hatcher et al., 1994) are not interpreted by the authors as straight support for the causal connection between phonological awareness and reading development proposed earlier (Bradley & Bryant, 1985). As Hatcher (1994) concludes,

> ... these findings cast doubt on the simple theory that there is a direct causal path from phonological skills to reading skills. Our data support the more subtle position that adequate phonological skills may be necessary, but not sufficient, for learning to read effectively. (p. 53).

Ironically, it is from this very point that proponents of the 'consequential' lobby take up their argument. Morais (1991b) acknowledges that aspects of phonological awareness, namely supraphonemic skills such as rhyming, can precede reading, but goes on to propose a multicomponential view of phonological awareness. From this viewpoint, he argues, explicit phoneme awareness, rather than indicative of the previously assumed developmental or spontaneous progression from early rhyming sensitivity, cannot develop outside the context of alphabetic instruction: 'experience of learning an alphabet is', Morais (1991b) contends, 'crucial.' (p. 44).

Cross-linguistic studies involving readers of non-alphabetic orthographies are most commonly reported by those who propose that phonological awareness arises from, or is enhanced by, learning to read in an alphabetic script.

1.6.3 Cross-linguistic Studies

In support of his claim above, Morais (1991b) cites his own study of Portuguese illiterates (Morais et al., 1979). Morais and his colleagues studied the phonological segmentation ability of two groups of Portuguese adults. Neither group received any reading instruction in childhood but all the members of one group had attended adult literacy classes and were therefore described as 'ex-illiterates'. Based on the results from a phoneme addition and a phoneme deletion task, Morais and his colleagues found the phonological segmentation ability of the 'ex-illiterates' to be significantly better than that of the other, still-illiterate group. The authors attributed the superior performance of the ex-illiterate group to their experience of learning to read. However, the conclusions that reading precedes phonemic segmentation must be tempered in the light of inconclusive evidence that the sample in this study was well-matched. As this was a single condition experiment and no other skills were assessed, it could be argued that the illiterate group, rather than experiencing a specific insensitivity to phonemes, was a-typical and less-able in general terms.

In an effort to address this, another cross-linguistic study compared phonemic sensitivity in two literate groups of Chinese speakers. Read, Zhang, Nie and Ding (1986) studied two groups of adults: the first group used only the traditional Chinese logographic system, while the second was also able to use alphabetic Chinese (pinyin). The two groups were given a phoneme deletion task and, as in the Portuguese study (Morais et al., 1979) the results suggested that those with no knowledge of an alphabetic principle were unable to complete the task. Whilst this would seem to support Morais' (1991a) claim that phoneme segmentation ability is not naturally acquired in the absence of an alphabetic script, the results are again weakened by insufficient detail of matching for IQ. It could also be argued that the study does not provide clear evidence of phonemic awareness in the 'alphabetic' group: by utilising the "fanzi" principle where Chinese syllables can be readily broken into onset and rime, the pinyin group could have satisfactorily completed the task at the intra-syllabic rather than phonemic level.

In a similar study, Mann (1986) studied a group of first-graders learning to read the Japanese Kana syllabary and the Kanji logography. On first testing most of the Japanese children scored below Mann's American control group in phoneme counting and deletion tasks. However, by the end of the study the Japanese children who still lacked both alphabetic knowledge and formal instruction performed at the same level as the American first-grade controls. Mann concluded from this that maturational status may be an important factor in the development of phonemic awareness. The study did not, however, consider any possible effects from training in an alphabetic orthography which may have taken place outside the school: it may be that the 'best readers' were already being trained in English at home. At the same time, Mann's study with young children would also seem to indicate the importance of teaching style in the development of phonemic awareness: in Japanese schools, the syllabic Kana is often taught through emphasis on shared phonemes (Goswami & Bryant, 1990). It could be argued from these results that experience of any phonological orthography rather than knowledge of a solely alphabetic system may promote phonemic awareness.

Evidence that it is possible to train phonological awareness in non-readers and poor readers and that such training may promote reading achievement would seem to lend support to the claim that phonological awareness is causal to reading development (Ball & Blachman, 1988; Bradley & Bryant, 1985; Hatcher et al., 1994). However, evidence from the crosslinguistic studies suggests that phonemic awareness develops as a consequence of learning to read in an alphabetic writing system.

Summary

The evidence presented here would seem to suggest that an interactional relationship, rather than a discrete causal or consequential relationship exists between phonological awareness and literacy. There is strong evidence that phonological awareness facilitates learning to read. The interactive view proposes conversely that reading may foster phonological awareness but it would appear also from these studies that a certain level of phonological awareness is necessary for learning about the relationship between printed and spoken words. The training studies discussed here would seem to concur concerning the importance of alphabetic knowledge to early reading. However, individual differences in reading ability cannot be attributed to alphabetic knowledge alone as, Stanovich and Stanovich (1995) contend, 'segmenting visual words into letter units is well within the perceptual capabilities of every non-impaired school-age child' (p. 94). It is, they propose, the association between the letters and the associated sound segments of speech (that is phonemic awareness) which most often distinguishes successful from poor readers. It would therefore seem that alphabetic coding is the critical subskill which underpins fluent reading. Several recent studies (Cataldo & Ellis, 1990; Huxford, 1993) have suggested that many children acquire this crucial alphabetic principle more readily through spelling than reading. The next section considers the relationship between phonological awareness and spelling.

1.7 Phonological Awareness and Spelling

As the previous sections have shown, there is extensive literature on the relationship between phonological awareness and reading development. By contrast, the association between phonological awareness and spelling seems to have attracted less attention. There is some evidence that children who read well usually spell well too (Gough, Juel & Griffith, 1992) and a spelling test developed by Mann (1991) for a longitudinal study of 85 kindergarteners demonstrated that early spelling ability was predictive of subsequent reading achievement ($r = .70$, $p < .001$).

1.7.1 The Relationship between Reading and Spelling

There is now some evidence that spelling plays an important part in reading development. Frith (1985) has suggested that while similar strategies may be employed for reading and writing, there may be an asynchrony between the two skills. Fig. 4 outlines the model but has been adapted by replacing Frith's term 'writing' with the term 'spelling'. Frith (1985) indicates by the direction of the arrows, the activity which is thought to pre-empt the development of a new strategy.

Fig. 4 Model of the Acquisition of Reading and Spelling (adapted from Frith, 1985)

Step	Reading	Spelling
1a	**logographic**	(symbolic)
1b	logographic	logographic
2a	logographic	**alphabetic**
2b	alphabetic	alphabetic
3a	**orthographic**	alphabetic
3b	orthographic	orthographic

According to Frith (1985), alphabetic spelling acts as the pacemaker for the shift to the use of an alphabetic strategy in reading and, she claims, for this reason, spelling may have more influence than reading in mastering the alphabetic principle. As

Stainthorp (1989) suggests, 'As children are writing, their attention must inevitably be drawn to the segmentational nature of the written word' (p. 193). In spelling then, children have to attend to both the sounds in a spoken word and each letter they write: several studies discussed previously have reported the benefits of linking phonological awareness to letter sounds (Bradley & Bryant, 1983; Hatcher et al., 1994).

Frith's model would seem to explain some reports that young children can spell words they cannot read (Bryant & Bradley, 1980): according to the model in Fig. 4, at the end of the first stage of reading development a child may be able to employ an alphabetic strategy for spelling but not yet be able to employ a similar strategy for reading.

Whilst no direct causal connection can be assumed between spelling and reading, there is some empirical evidence that phonological spelling precedes phonological reading. In an eight-week longitudinal study of 43 children (mean age 5 years 5 months), mean spelling scores were found to be consistently higher than reading scores (Huxford, 1993). Results from this study suggested that performance on a phonological segmentation task was significantly better than performance on a phonological blending task. This prompted the conclusion that differences in spelling and reading ability were independent of alphabetic knowledge (Huxford, Terrell & Bradley, 1991). Conversely, Stuart (1990) reported from her study of eight nursery-aged children, that the children 'were able to use whatever segmentation and sound-letter correspondence knowledge they had .... to help them to attempt to spell nonwords' (p. 145).

The report that 'at one point in their progress in the study, most children were able to give the sounds of the letters in the words they were asked to read but unable to connect the letters in order to read the words' (Huxford et al., 1991, p. 104), would not only seem to be in line with the earlier proposal that knowledge of letters of the alphabet is not sufficient for the alphabetic principle to develop (Byrne & Fielding-Barnsley, 1989), but may be related to a second phonological processing skill, phonological memory.

Summary

The studies reported in this section suggest that phonological spelling may precede phonological reading. This would seem to suggest that assessment of spelling ability together with assessment of alphabetic knowledge may provide useful information regarding a child's stage of phonological development.

This chapter has discussed a number of studies and a variety of tasks which have been used previously in the assessment of phonological awareness in young children. The review of the literature has revealed that a broad range of tasks has been used in the assessment of phonological awareness in children of varying ages and literate status, non-readers, beginning readers, poor readers and good readers.

The next chapter considers another phonological processing skill which has also been cited in studies of reading development, phonological memory.

CHAPTER 2

PHONOLOGICAL MEMORY

Introduction and Outline of Chapter

Over the past decade, much research interest has focused on the cognitive processes which are thought to underpin language development. The previous chapter considered the frequently researched and well documented relationship between one phonological processing skill, phonological awareness, and the acquisition of literacy. More recently, there has been a growing interest in another phonological processing skill, phonological memory.

The short term memory capacity of a child is thought to treble between the ages of three and fourteen years (Case, Kurland & Goldberg, 1982; Chi, 1976). Although the literature on phonological memory in young children is still substantially less than the literature on phonological awareness in young children, a fast growing number of studies has now begun to investigate this dramatic developmental change (for example, Nicolson, 1981; Hulme, Thomson, Muir & Lawrence, 1984). Much of this research interest has focused specifically on the components of working memory thought to be involved in language development (for example, Gathercole & Baddeley, 1990a; Service, 1992).

This chapter begins by reviewing the literature on some earlier theories of working memory and then discusses a more contemporary theory which has stimulated much of the research interest in working memory and language development.

The literature is discussed under the following headings :

- theories of short-term memory
- the working memory model (Baddeley & Hitch, 1974)
- the phonological loop
- the phonological store
- the articulatory rehearsal system
- phonological memory and speech rate
- tests of memory
- phonological memory and language development

2.1 Theories of Short Term Memory

Some of the most influential models of memory have described memory as consisting of two components or stores, the long term and the short term store.

Miller (1956) proposed that variation in short-term memory capacity may be explained by the notion of 'chunking' where, rather than each individual item occupying a single slot, information could be 'chunked' so that each slot contained several related pieces of information. Miller estimated that seven 'chunks' of information could be held in short-term memory at any one time. The crucial point here would seem to be that Miller's 'chunks' are defined as 'any familiar unit of information based on previous learning' (Cohen, Kiss & Le Voi, 1993, p. 68) for example, numbers, letters or words.

Atkinson and Shiffrin (1968) extended this rudimentary theory and proposed short-term memory to be one of several different storage components within a more general memory model. Capacity within the store was limited by the number of available 'slots' within which information could be retained. In this model, short-term memory capacity was seen as limited by the amount of storage space available.

While these earlier theories ascribed limitations in short term memory to structural constraints, the discovery that memory for longer words or phrases was less efficient than memory for shorter words (Simon, 1974), caused research interest to focus more closely on processing limitations, particularly those associated with the allocation of attention. Attentional capacity is reported to limit the number of items which can be attended to at any one time. According to the most recent theories, short term memory plays a fundamental role in appropriating attention by actively selecting and processing incoming information (Baddeley & Hitch, 1974).

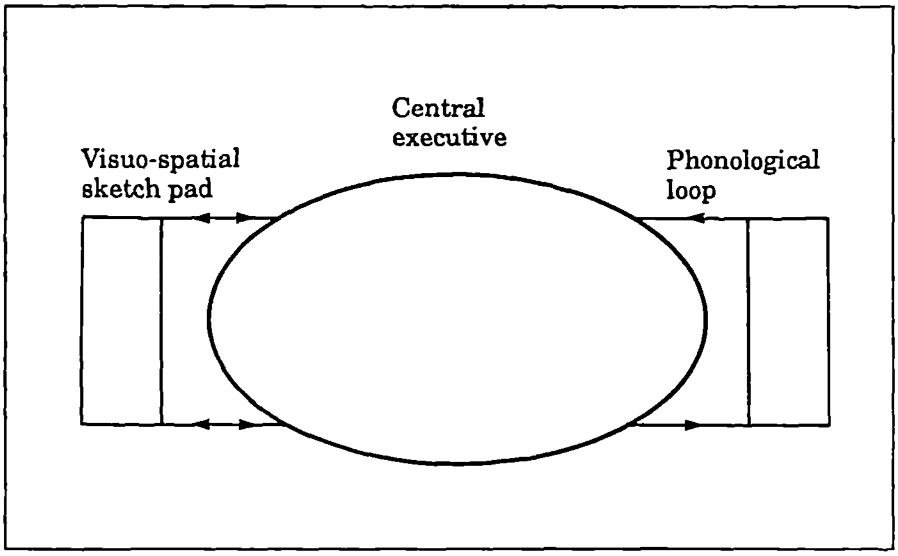
The idea of short-term memory as a psychological mechanism actively involved in a range of cognitive tasks prompted specific models of 'working memory'. Much of the intensive research activity over the last ten years has been fostered by interest in this more functional view of short term memory. However, cross-study comparison and evaluation has been impeded by the apparently inconsistent use of the term 'working memory'. Some psychologists define 'working memory' as a limited-capacity processor (for example, Daneman & Carpenter, 1980) while others propose it to be a limitless component of general cognition (for example, Anderson, 1983).

Baddeley and Hitch (1974) proposed a model where 'working memory' is seen to incorporate both temporary processing and temporary storage of information. This model, where short term memory is now conceptualised as a time-limited store, has provided a particularly useful framework in studies investigating the role of memory in language development (for example, Gathercole & Adams, 1993; Gathercole & Baddeley, 1993a).

2.2 The Working Memory Model (Baddeley & Hitch, 1974)

According to this model (Baddeley & Hitch, 1974), working memory is thought to compose of three components: the central executive and two supplementary slave systems, the visuo-spatial sketchpad and the phonological loop. Fig. 5 illustrates the framework of this componential model.

Fig. 5 The Working Memory Model (from Baddeley & Hitch, 1974)



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The central executive is seen as the most important element of the model as it is involved in any cognitively demanding task. Unlike the two slave systems, the central executive is thought to process information from any sensory modality. Its major function is as a control mechanism: processing and allocating incoming information to each of its slave systems; storing information temporarily and retrieving information from other parts of the memory system such as the long-term store. The processing capability of the central executive is thought to be limited in capacity but is supplemented by the two slave systems. These two slave systems each specialise in the processing and temporary storage of information from particular sensory domains.

The visuo-spatial sketchpad processes visual and spatial material transmitted from the visual sensory register. It is also thought to store and retrieve from the long term store any material which has been encoded in pictorial form. The ability to identify the handwriting on an envelope is reported to be one example of visuospatial sketchpad functioning (Cohen et al., 1993).

Although visual memory skills have been found to increase with age (Wilson, Scott & Power, 1987), several cross-sectional studies (Hitch & Halliday, 1983; Hitch, Halliday, Schaafstal & Schraagen, 1988) suggest that in recall tasks, younger children depend more on a visual strategy than older children, who demonstrate a preference for verbal strategies. In one of these studies (Hitch et al., 1988), use of the visuo-spatial sketchpad was tested by giving a serial recall task to one group of five year old children and another group of ten year old children. The children were shown three sets of picture cards. In one set, the pictures were all visually similar with monosyllabic names, such as *nail, spade, comb,* and *saw.* The second set contained pictures of visually dissimilar items with multisyllabic names such as *banana, kangaroo* and *umbrella.* The final, control set depicted visually dissimilar items with short names, for example *leaf, pig* and *cake.* Based on results from an earlier study (Hitch & Halliday, 1983), it was predicted that recall in the younger children would be poorer for the visually similar set of cards but their scores for the visually dissimilar set were expected to be relatively better. This prediction was partly borne out by the results. As expected, the younger children performed poorly in the visually-similar condition but, contrary to prediction, they were not unaffected by the longer names of the visually-dissimilar stimuli. The older children, aged ten years, were uninfluenced by the visually similar pictures, but had significantly greater difficulty in remembering pictures which had 3-syllable rather than 1-syllable names.

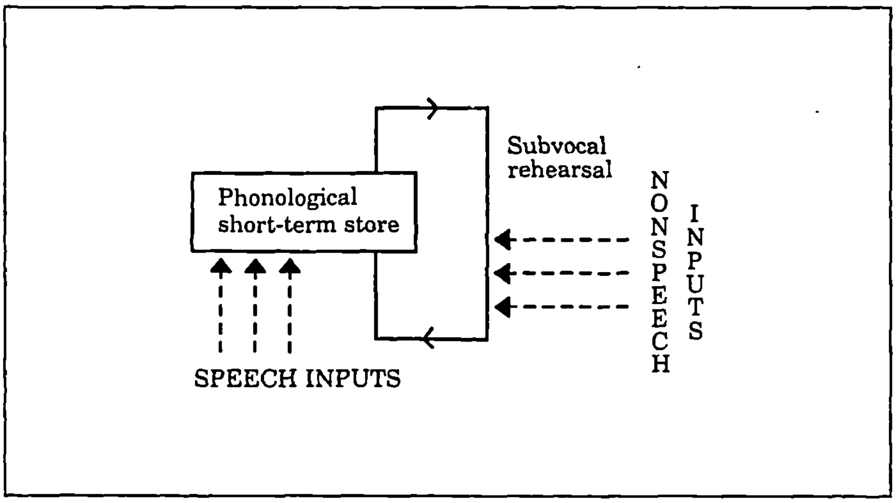
The authors reported this to be evidence that the younger group relied on visual memory strategies while the older group were reliant on verbal memory strategies. No explanation is given regarding the unexpected difficulty of the five year olds in remembering the 3-syllable names. As it has been proposed that verbal memory skills are activated by learning to read (Longoni & Scalisi, 1994) and it could be assumed all the older children were readers, some measure of reading ability in the younger group may have clarified whether this could have influenced their performance.

Despite this observed tendency of young children to remember pictures in terms of their visual characteristics, results from a growing number of studies suggest that all three components of working memory are operational from about four years of age (Gathercole & Baddeley, 1993). However, most experimental studies of working memory development have looked particularly at the changes which are thought to take place in the phonological loop. According to Baddeley and Hitch's (1974) model, the phonological loop is the slave system responsible for processing and storing verbal items and is thought to play a significant role in language development.

2.3 The Phonological Loop

In the original model of working memory (Baddeley & Hitch, 1974), the phonological loop was hypothesised to be a unitary mechanism for processing all verbal information. However, based on evidence from a subsequent series of experimental studies (Baddeley, 1986), the phonological loop is now thought to consist of two interactive components: a passive phonological store and a covert articulatory rehearsal system. In this version of the working memory model, both components of the phonological loop are presumed to employ <u>phonological</u> coding. The revised dual component model of the phonological loop is shown in Fig. 6.

Fig. 6 The Phonological Loop (from Baddeley, 1986)



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The first component of the loop, the phonological store, is a fast-decaying store where material is retained in phonological code. Spoken language gains direct access to the phonological store and, as a result, the store has earned the title 'the inner ear' (Baddeley, 1990). Information is thought to enter the phonological store in three different ways. First, auditory or spoken information appears to have direct access to the store. Second, written or pictorial material gains access via the articulatory rehearsal system where it is converted into a phonological code before being registered in the store. Third, information stored in a verbal form can be retrieved from the long-term store and enters the short term store in a speech based code. According to this model, memory traces of speech-based information held in the phonological store decay in about 1.5 - 2 seconds.

The other component, the articulatory rehearsal system, has been labelled 'the inner voice' (Baddeley, 1990). This rehearsal system serves to refresh diminishing codes in the phonological store and is also thought to store words prior to articulation including phonological representations retrieved from long-term memory. It also plays an 'interpretative' role, translating non-phonological information, such as printed words or pictures, into a phonological form for short or long-term storage.

A range of experimental procedures has been developed to investigate these two components of the phonological loop.

2.4 The Phonological Store

Baddeley (1986) suggests a clear distinction between the articulatory rehearsal system and the phonological store. Input to the phonological store is modality-dependent: auditory input gains direct access to the store whereas visually presented material has first to be 'translated' into a phonological code before storage can take place.

Developmental studies of the phonological store typically incorporate tests of acoustic, phonological, or phonemic similarity. Whilst all appear to relate to the same phenomenon, the three terms appear to be used interchangeably in the literature.

2.4.1 The Phonemic Similarity Effect

The phonological similarity effect was first identified in two adult studies by Conrad (1963; 1964). In the first study (Conrad, 1963), immediate recall of lists of words was found to be significantly impaired if the words were phonologically similar, for example *cat, rat* or *mat* were reported to be more open to confusion than *man, wall* or *fish*. In the second study (Conrad, 1964), the same effect was found with memory for single letters when the stimulus items were presented visually on projector slides: recall of phonemically similar letters such as 'b', 'p', 'c' was significantly poorer than recall of 'm, 'w', 'f'. These studies seem to indicate that adults implicitly categorise words phonologically, based on common sounds.

A further study by Conrad (1971) investigating the development of covert speech, proposed a different pattern of this effect in young children. This time working with children aged between three and eleven years, Conrad again presented a serial recall task using two sets of drawings of familiar objects. Again, in one set, the names of some objects were phonologically similar, for example *rat, tap* and *mat*, while in the other set, the names were phonologically dissimilar, *girl, spoon* and *horse*. The results suggested that up to the age of five years, the children remembered the two types of pictures and their names equally well. However, beyond the age of five years, Conrad observed, there was a progressive advantage for remembering words with dissimilar names. As phonologically similar words, for example *cat* and *rat* are only distinguishable by one sound, losing the first sound from *cat* and the first sound from *rat* would render them in-discriminable. Conrad claimed these results were evidence that the older children (five years of age and older) had labelled the pictures and were therefore confused by similarity in the names. The younger children however were not confused by similar sounding names because they had not 'translated' the pictorial stimuli into a phonological code but, Conrad assumed, were using a visual memory strategy for recall. The poorer recall of phonologically similar items has been observed in a number of other studies and is now generally attributed to the problem of discriminating between partially decayed, structurally similar traces in the phonological store (Salame & Baddeley, 1982).

Closer examination of the methodology in Conrad's study, however, would suggest that as the experimenter named each picture, presentation was both auditory and visual. As auditory material gains direct access to the phonological store, it is unclear why the younger children were not sensitive to the similarity of the names.

2.4.2 Modality of Presentation

A subsequent study of 112 children ranging in age from four years to ten years, used auditory presentation only to repeat the serial recall task using Conrad's stimulus vocabulary (Hulme, 1984). Results were similar to those from the earlier study (Conrad, 1971) where phonological similarity had no reliable effect on the recall of children under the age of five years, but had progressively more effect on the older children up to the age of ten years. No measurement of general cognitive ability was taken and the apparent discrepancies in mean span scores (3.3 at age seven years and 3.4 at age four years, five years, six years and nine years) would seem to suggest the groups may not have been appropriately matched. It could also be argued that, despite the size of the overall sample, the individual groups in this study were too small (n = 16) for any absolute conclusions to be made regarding the cross-modality consistency of the phonological similarity effect.

To further investigate the phonological store component of working memory, the phonological similarity effect has been tested using the articulatory suppression technique.

2.4.3 Articulatory Suppression

Articulatory suppression involves the repetition of an irrelevant word or words during presentation of the list to be recalled. The assumption is that, in the articulatory suppression condition, rehearsal is actively eliminated by the demand for simultaneous repetition of an unconnected word such as 'the' (Baddeley, Lewis, & Vallar, 1984). If performance on the serial recall task is noticeably impaired by articulatory suppression, then it can be assumed that articulatory rehearsal is necessary for accurate recall.

One adult study (Baddeley et al., 1984) investigated the effects of articulatory suppression on the phonological similarity effect. The results demonstrated that with visual presentation there was no longer a significant phonological similarity effect. However, with auditory presentation, the phonological similarity effect was found to remain. The explanation for this selective effect is most readily explained by the influence of modality of presentation on access to the phonological store. With visual presentation, material has first to be recoded via the articulatory rehearsal system; when rehearsal is blocked, an alternative visual strategy is invoked and so neither access to nor confusion in the phonological store can occur. However, as spoken material is thought to gain direct access to the store, even when rehearsal is prevented, phonologically similar words are more likely to be confused before recall. In order to evaluate this proposal further, the development of the effect in children has been monitored.

A particularly different picture of the phonological similarity effect under articulatory suppression emerges from studies of children. The first part of one study (Halliday, Hitch, Lennon & Pettifer, 1990), replicated findings from previous studies of phonological similarity where, with pictorial presentation, younger children (below five years of age) were unaffected by phonological similarity whereas older children demonstrated significantly lower recall for lists of similar sounding words. In the second part of the study, employing an articulatory suppression condition, the performance of the younger children was again unaffected by the phonological structure of the lists, but, as in the adult study, the older children no longer demonstrated the phonological similarity effect.

2.4.4 Modality of Output

Another explanation of the apparent developmental nature of the phonological similarity effect, has centred on the output effect. In a study which employed auditory input but a probed recall which demanded no full verbal output, the similarity effect was evident in a group of seven year olds but not in the group of five year olds (Henry, 1991a). From these findings it was proposed the phonological similarity effect demonstrated by some children in earlier studies (Hulme, 1984) may be attributed to output difficulties rather than storage difficulties. However, this experiment did not require full list recall: task demands between probed and serial recall may account for the discrepancy in findings.

Summary

Evidence that auditorily presented material has an 'obligatory' access to the phonological store is not consistent with other findings that children become gradually more aware of phonologically similar sounds (Hulme, 1984). If, as the Baddeley and Hitch model (1974) proposes, auditorily presented material demands no subvocal recoding, then the phonemic similarity effect should be observed across a range of ages. One explanation could be that if, as has been proposed, speech rate increases developmentally so the number of words admitted to the store via the loop increases (Hulme & Tordoff, 1989). Although more words are stored, discriminating between phonologically similar words does not apparently become more proficient. Therefore, in absolute terms, the difference between recall of similar and dissimilar words increases, suggesting somewhat spuriously that sensitivity to phonological similarity increases with age. In a longitudinal developmental study, it may be possible to simultaneously assess the phonological similarity effect in children who may or may not be successful on phonological awareness tasks of rhyme detection.

Variation in short term memory capacity is thought to relate to the speed at which information held in the phonological store can be rehearsed. The next section discusses the development of the articulatory rehearsal system.

2.5 The Articulatory Rehearsal System

According to the Baddeley (1986) model, the process of subvocal rehearsal serves to refresh phonological information as it begins to decay in the phonological store. Several techniques have been developed to investigate this rehearsal process. From the literature, one of the most commonly used experimental techniques is that which assesses the 'word length' effect.

2.5.1 The Word-Length Effect

Baddeley, Thomson and Buchanan (1975) demonstrated that adults' immediate memory recall was significantly better for words which were of short spoken duration, for example *mumps*, *sum* or *hate*, than for lengthier words such as *aluminium*, *university* or *hippopotamus*. From findings in this study it was concluded that short words were recalled more accurately because, it was argued, they could be rehearsed more often than long words in the limited time capacity of the rehearsal system. The results were taken as evidence that the articulatory rehearsal system has a temporally limited capacity and that rehearsal takes place in real time. The significant relationship found between memory span and the time taken to repeat the words used ($r = .69$, $p < .001$)) would seem to lend further support to this.

2.5.2 Articulatory Suppression

To test this rehearsal mechanism further, an articulatory suppression technique was included in the study (Baddeley et al., 1975). The assumption is that this overt articulation involves the articulatory rehearsal system; if performance on the serial recall task is impaired, then it can be claimed that this too demands use of a rehearsal mechanism. In this condition, it was claimed, the word length effect for visually presented material was no longer evident in the articulatory suppression condition. However, this claim must be weakened as no visually presented stimuli were used in the first experiments to test the word length effect. Although the sample in this study was very small (eight undergraduates) the results have been regularly cited (for example, Hitch, Halliday, Dodd & Littler, 1989a) as evidence that the word length effect arises from rehearsal, a process which, it is assumed, is disrupted by irrelevant articulation. However, a less cited finding from this study would seem to be that the word length effect continued to occur even with articulatory suppression when the stimulus material was presented in auditory form. Baddeley and his colleagues (1975) proposed that this may suggest that 'articulation [is] a means of converting the visual stimulus into a phonemic code which may be accepted by some form of storage system' (p. 587). The importance of modality in assessing the proposed components of the phonological loop is particularly evident in studies of developmental changes in the working memory of children.

Developmental studies of working memory have suggested quantitative differences between the short-term verbal storage capacities of young children and adults (Case et al., 1982; Halford & Wilson, 1980). Typically, a child of four to five years of age is able to recall approximately two or three digits when given an auditorily presented serial span test (Elliott et al., 1983) whereas a child of eleven years of age may be expected to recall six digits serially. It is widely thought that this expansion in span can be attributed to a qualitative difference in memory function, that is the gradual development in subarticulatory rehearsal from early childhood. Studies of the word length effect in children have resulted in conflicting ideas as to when, and if, young children engage in subvocal rehearsal.

The proposal that children did not engage in subvocal rehearsal until about seven years of age would seem related to Vygotsky's (1962) claim that verbal material can only be successfully maintained in memory when overt articulation becomes internalised as 'inner speech'. Evidence of a developmental increase in subvocal rehearsal has come from studies of serial recall which report children from the age of seven employing observable rehearsal behaviours, such as lip-movements and whispering (Flavell, Beach & Chinsky, 1966). Children who exhibit these behaviours have been found to perform more successfully on memory tasks than children who do not (Keeney, Canizzo & Flavell, 1967).

2.5.3 Modality of Presentation

One influential study (Hitch & Halliday, 1983) paid particular attention to the issue of modality of presentation. Words of varying length (one, two and three syllable) were presented to three groups of children (mean ages 5.11 years, 7.8 years and 10.3 years). In the first condition, the experimenter spoke the words to be remembered and in the second condition there was no auditory input, the children were simply shown a serial group of pictures. As in adult studies of the word-length effect, for all the children the verbal recall of short words exceeded the recall of longer words. However this was the case only in the auditorily-presented condition. In the second, pictorial condition, the youngest group of six year olds displayed no significant word length effect and recalled short and long words equally well. There was also little evidence of the word length effect in the eight year old group. However, an analysis of simple effects revealed a significant interaction between word length and stimulus condition in the group of ten year old children. This was thought to indicate a qualitative difference in memory for auditory and visual stimuli and conforms to Baddeley's (1986) model where, it is proposed, verbal material gains direct access to the phonological store whilst visual material has to be recoded via the articulatory rehearsal system.

These findings have been replicated a number of times (for example, Halliday et al., 1990; Hitch et al., 1989) although the findings of one study are in marked contrast (Hulme et al., 1984). Memory span for pictorially presented words of one or three syllables was tested in a sample of four, seven and ten year old children. It was observed that all were more readily able to recall short words than long words. This led the authors to assume that even the youngest children in the study were employing subvocal rehearsal to recode the visual stimuli into a phonological form for recall. The apparent discrepancy of results between these studies may be explained by inconsistencies in the methodology employed in the later experiments. Although visually presented stimuli were used in the study by Hulme (1984), it was reported that many of the youngest children spontaneously 'labelled' the pictures. It could be argued, therefore, that the children in this experiment were, in fact, reciting a list and then responding to the stimuli via an auditory rather than a visual input modality.

2.5.4 Modality of Output

In addition to 'input' modality, one recent study has considered the significance of 'output' modality in assessments of the word-length effect in young children. In a well-designed study, Henry (1991) carried out two experiments of the word-length effect in children. In the first, two groups of children (n = 64) aged five and seven years were given a serial recall task where they were asked to repeat lists of one, three or four syllable words. To avoid any possible ceiling or floor effects, list lengths were controlled based on previously assessed span limits. In line with the results from earlier studies (for example, Hitch et al., 1989; Hulme et al., 1984) the word length effect was evident in both age groups when the task was auditorily presented and demanded full verbal recall. In the second experiment however, the results were quite different. In the probed recall task, the experimenter named a set of picture cards before turning them face down. There were then two conditions: in the first the child had to name the card touched by the experimenter; while in the second the child had to touch the card the experimenter named. The results were the same in both conditions: the older group of children displayed the word-length effect while the younger children were unaffected by word length. Henry concluded that the word length effect evident in the younger children in the first experiment could therefore be attributed to loss of phonological traces during output rather than during rehearsal at input.

Results from the first experiment would suggest that even the youngest children were employing subvocal rehearsal for serial recall; whereas in the probed recall task this may not have been the case. The serial recall task was presented in a purely auditory form, whereas the probed recall task employed both auditory and visual picture cards. As young children are less likely to recode visual stimuli into phonological form (Hitch et al., 1988), these discrepancies in results reflect use of a rehearsal strategy only for auditory material. Similarly, as young children are thought to acquire oral language through imitation (Vygotsky, 1962) there is some evidence they can be trained to rehearse subvocally; Johnston, Johnston and Gray (1987) demonstrated the word length effect in a group of five year old children who had been taught to recite a serial list once before recall. It could be argued that auditorily presented span lists may actively encourage rehearsal strategies and that serial recall tasks encourage rehearsal strategies earlier than tasks of probed recall.

Summary

The results from the studies reported here have been taken as evidence that both components of the phonological loop, the phonological store and the articulatory rehearsal system are operational in children as young as four years of age. There is still some uncertainty whether young children do employ rehearsal techniques in the same way as older children and adults.

Further evidence of the word-length effect as an indicator of subvocal rehearsal arises from studies which investigate the relationship between speech rate and short term memory. The next section reviews the literature on phonological memory and speech rate.

2.6 Phonological Memory and Speech Rate

The proposal that memory span increases with age has been well documented (for example, Chi, 1976). However, the reasons for this proposed increase are still unclear. In an attempt to explain the developmental increase in memory span, a number of studies have focused specifically on the relationship between speech rate and working memory (for example, Hitch & Halliday, 1983; Hulme et al., 1984; Hulme & Tordoff, 1989; Nicolson, 1981).

The working memory model (Baddeley & Hitch, 1974) suggests articulatory rehearsal operates in real time. The number of items maintained in the articulatory loop may therefore be dependent on how many can be refreshed before the phonological traces are no longer distinguishable. Words which take longer to articulate take longer to rehearse and, as a result, maintenance in the phonological store is thought to deteriorate between successive rehearsals. In support of the suggestion that sub-vocal articulation may correlate directly with overt speech rate, there is some evidence of an association between memory span and speech rate in adults (Baddeley et al., 1975; Hulme et al., 1984).

2.6.1 Span and Speech Rate in Children

In an effort to explain the assumed developmental changes in short-term memory, a number of studies have investigated the relationship between recall and articulation speed for words of different lengths in children of different ages (for example, Hitch & Halliday, 1983; Hulme & Tordoff, 1989).

One early study (Nicolson, 1981) found a direct linear relationship between articulation rate and memory span for a series of words in a sample of eight, ten and twelve year old children. Across all ages, the same word-length effect was noted: serial recall of short words which could be spoken rapidly was better than serial recall of longer words which had a slower articulation time. Results in this study, however, may have suffered a 'modality' effect. The words were all visually presented and therefore had to be 'read' by the children; as differences in reading ability were not controlled, it could be argued children who were better readers were able to perform more successfully on the task.

In an attempt to redress this, Hitch and Halliday (1983) used both picture and spoken word stimuli to assess speech rate and recall in children of six, eight and ten years of age. The word-length effect was again noted across all ages with the spoken stimuli and the increase in speech rate in age closely matched the increase in memory span.

Hulme et al. (1984) used only auditory presentation in a study investigating the relationship between word length, speech rate and memory span. Working across a broad age range (four, seven and ten years), Hulme and his colleagues found a strong correlation between speech rate and memory span. They proposed that a child's memory span is directly related to the number of items he or she can articulate in 1.5 seconds. This straightforward interpretation has also been applied to studies of other languages.

Differences between digit-span scores of English-speaking children and a matched group of Welsh-speaking children have been explained in terms of the shorter articulatory duration of English digits (Ellis & Hennelly, 1980). To test this relationship further, Raine, Hulme, Chadderton and Bailey (1991) studied a group of speech-disordered children to investigate whether pathologically slower articulation rates would detrimentally affect memory span. Significant differences were found between short term memory span and speech rates of the speech disordered group compared with an age-matched control. When speech rate was entered as a covariate, differences in memory span were no longer found.

Again, evidence of a true association between speech rate and phonological memory is often unclear because of the way in which data have been reported. For example, the linear relationship between speech rate and memory claimed by some studies (Hulme et al., 1984; Raine et al., 1991) has been based on group correlations. This has involved calculating average scores for each age group for memory span and speech rate and then comparing these summary measures. These group correlations, it could be argued, may have masked differences within the groups and led Henry (1991b) to recommend that the relationship between memory span and speech rate should be investigated within age groups rather than across age groups. This recommendation would seem to be endorsed by the findings of one large longitudinal study of 70 four and five year old children (Gathercole & Adams, 1994). In this study, a significant correlation was reported only between digit span scores and speech rate at the second wave of testing when the children were five years of age. From the data, it would also seem that the relationship between speech rate and a second measure of phonological memory, nonword repetition ($r = .42$, $p <.001$) was also highly significant only at the second wave of testing.

Although differences in speech rate seem related to differences in memory span, these findings are generally correlational and cannot rule out the possibility that other factors may be involved in the development of memory span. In order to investigate the nature of the association between speech rate and memory span further, one study attempted to train a sample group of seven year olds in rapid articulation (Hulme & Muir, 1985). Training failed to improve either speech rate or memory span. Henry and Millar (1991) also investigated the relationship between memory span and speech rate, this time with a sample of five and seven year old children. Although word lists were equated for the speed at which each age range could articulate them, there were still marked differences in memory span between the age groups. This led Henry and Millar (1991) to suggest that speech rate may not be the only determinant of developmental differences in memory span. Alternative explanations have been put forward for the developmental increase in memory capacity and the proposed association between speech rate and memory span. The first alternative has centred *on identification time.*

2.6.2 The Item Identification Alternative

Several studies investigating the developmental increase in memory span have assessed the time taken between presentation of and response to stimulus words in memory span tasks. In a series of experimental studies (Case et al., 1982), the item identification time of children between the ages of three and six years was compared with that of a group of adults. A direct linear relationship was found between memory span and response time: as age and memory span increased, identification time decreased. It was therefore claimed (Case et al., 1982) that as general memory processing skills, such as speech perception and speech programming, become more efficient, so more memory space is available for storage of phonological codes. Young children with slower identification time were therefore assumed to have less capacity for remembering stimulus items. Results from these studies which suggested memory span was significantly associated with identification time may, however, have been influenced by the disparate types of stimuli used: the children were given words with which they were presumed to be 'familiar', while the adults were given nonsense words which they had recently learned. It cannot therefore be assumed that the association between identification speed and memory span would have been the same for words within the same familiarity class.

A subsequent series of experiments (Hitch, Halliday & Littler, 1989b) compared the relationship between memory span and both articulation rate and item identification time. Working with groups of children between eight and eleven years of age, Hitch et al. suggested that identification time may reflect the function of the central executive component of working memory rather than the phonological loop. Using stimuli of two and three syllable words, the authors found speech rate to be a better predictor of memory span than measures of identification time. Yet, the claim that the association between speech rate and phonological memory may be attributed to subvocal rehearsal during input of information has been recently challenged by theories which have focused on the output processing rather than the input processing of memory function.

2.6.3 The Verbal Output Alternative

This alternative to Baddeley's (1986) 'overt speech rate/covert rehearsal' model has come from a series of studies including one where no association was found between speech rate and memory span in a group of four year old children (Cowan et al., 1992). The results from this study did however suggest a significant relationship between memory span and the actual duration of recall. According to this theory, it is the duration rather than the rate of speech which is relevant. Significantly better memory performance was noted in children who, it was assumed, were able to maintain the memory trace well enough during recall to respond for five seconds than for children who were able to respond for only two seconds. This finding brings into question the previously assumed 1.5 second time limit of the phonological store component of working memory and has led to some debate whether or not rehearsal is necessary for recall of relatively short auditorily presented items (Henry, 1994).

2.6.4 The Phonological Readout Alternative

Closely akin to the verbal output alternative is the phonological readout hypothesis most recently proposed by Gathercole and Hitch (1993). This theory most readily accommodates the paradoxical finding that very young children, who are not thought to actively rehearse auditory memory lists, have been found to demonstrate the word length effect (Hitch, Halliday, Schaafstal & Heffernan, 1991). The phonological readout process is thought to influence the efficiency with which phonological representations in the phonological store are mapped onto articulatory gestures and subsequently overtly articulated (Gathercole & Hitch, 1993). Recall of lists is thus inferior to recall of single items because lists take longer to read-out from the phonological store into the articulatory motor system and the memory traces therefore are subject to greater delay. Actual speech rate, according to this theory, may be an index of the speed at which items in the phonological store can be 'translated' into articulatory form prior to output. If this readout process is efficient, then subvocal rehearsal of items to prevent decay at input may not be necessary.

2.6.5 Measures of Speech Rate

It may be argued that some ambiguity in studies of the relationship between speech rate and phonological memory arises from the different modes of presentation, stimuli and methods of scoring. Nicolson (1981) presented the stimulus words in printed form and this study may therefore have measured reading ability. Clearly, written words would be inappropriate for children at a preliterate stage.

Hitch and Halliday (1983) found no evidence of word-length effects in six year old children when the memory stimuli were pictorially presented. They concluded that children below the age of seven years do not use subvocal rehearsal to maintain the names of pictures. However, it has been suggested that children as young as four years of age use subvocal rehearsal when memory stimuli are presented in an auditory form (Hulme et al., 1984). From a developmental viewpoint, phonological recoding of nonauditory stimuli does not appear to emerge until later and full use of a rehearsal strategy, it has been claimed, may occur only as a result of becoming a proficient reader (Gathercole & Baddeley, 1993a).

The speed with which groups of words can be repeated has been frequently cited as a measure of the efficiency of subarticulatory rehearsal (for example, Hulme et al., 1984; Raine et al., 1991). In one study of eight year old children, a predictive relationship between speech rate and reading skill was found when children were asked to repeated triads of 'short', 'medium' or 'long' words ten times (McDougall et al., 1994). It would seem the strength of this association must however be weakened by the authors' report that the short words may in fact have been more familiar to the children than the medium and long words. It has also been suggested from an analysis of the intervals between words in this type of list, that articulation rates of individual words, rather than groups of words, may offer the most age sensitive measure of rehearsal speed (Hulme et al., 1984). A further proposal suggests that the stimuli used for the assessment of speech rate in a particular group should, ideally, be the same stimuli as that presented for the memory span tasks (Hulme et al., 1984).

The wide variety of stimulus items used in tests of speech rate would seem to have been matched by the diversity of methods and units of measurement. Measuring speech rate in words per second would seem to demand a particularly accurate and sensitive measure. Several studies have used stopwatches to measure the rate of 'live' production (for example, Henry, 1994); others have recorded the speech and measured the rates later using a stopwatch (for example, Hulme & Tordoff, 1989); and others have produced results by calculating a mean score in words per second and comparing scores awarded at the time of testing with audio recordings taken simultaneously (Gathercole & Adams, 1994). From the literature, computers have been frequently used to present visual stimuli for memory span tasks. More recently they have also been used for the auditory presentation of word lists in span tasks because 'the computer ensures that uniform procedures are used across different subjects and experiments and lessens the burden of running the experiments.' (Cox, Hulme & Brown, 1992, p. 575). Measuring speech rate which is recorded on a computer would seem to offer a consistency currently lacking in the assessment of speech rate.

Summary

Although no causal conclusions can be drawn from these studies, it would seem plausible that a positive association between speech rate and phonological memory span could reflect a subarticulatory rehearsal procedure. However, findings from other studies have indicated that factors other than speech rate may also contribute to performance on memory tasks (Hulme, Maughan & Brown, 1991). Gathercole and Adams (1994), failing to establish any significant correlation between memory span and speech rate in a sample of four year olds, have cited the supplementary contribution made by long-term memory to tasks which purport to assess short term memory function.

The studies discussed here have illustrated the importance of test design and methodology in the assessment of speech rate. The next section discusses the assessment of short term memory.

2.7 The Assessment of Memory

Results from one adult memory study (Hulme et al., 1991) have proposed that performance on immediate memory tasks may incorporate long term memory knowledge as well as phonological processing in short-term memory. In this study, although a linear relationship was found between span and speech rate, memory span for nonwords was lower than span for real words. Recall of nonwords was poorer, it was assumed, because no supporting phonological representation was available in long term memory. A similar effect was observed in a study of children between the ages of six and ten years (Roodenrys, Hulme & Brown, 1993) where frequency of the stimulus words accounted for differences in memory performance more than the rate at which the words could be articulated.

There is some evidence that memory measures taken on school entry (around five years of age) provide useful predictors of both subsequent vocabulary knowledge and reading achievement (Gathercole & Baddeley, 1993b; Gathercole et al., 1992). For this reason, early screening inventories often include tests of phonological memory. As they are thought to be relatively unaffected by a child's cultural experience, most include lists of items which are familiar to all young children (for example, digits or words from a corpus of spoken vocabulary for very young children) or nonwords which are equally *unfamiliar* to all children.

2.7.1 Digit Span Test

A digit span task, commonly used in clinical and educational psychology assessments, is a measure of the maximum number of digits which can be recalled in forward or backward sequence (for example, Elliott et al., 1983; Weschler, 1974). However, it has been argued (Gathercole & Adams, 1993) that superior performance on this type of task could be influenced by the child's familiarity with the domain from which the memory items are selected. In this way, children who are familiar with numbers may have developed a substantial long term store which aids retention of the number sequence. In addition, the phonological memory span of young children is thought to be relatively poor: typically at age four years, only two or three words can be remembered in sequence (Hulme et al., 1984; Hulme & Tordoff, 1989). There is also some evidence that performance on serial recall tasks may be influenced by the efficiency of subvocal rehearsal (Halliday & Hitch, 1988). In a large longitudinal study (n = 111), the significant correlation between speech rate and digit span at age five years but not at age four years was taken to suggest that subarticulatory rehearsal emerges somewhere between the age of four and five years. No equivalent correlation was however found between speech rate and the alternative measure of phonological memory, nonword repetition (Gathercole & Adams, 1994). As rehearsal in young children may be qualitatively different from that employed by adults (Gathercole & Hitch, 1993), tasks which involve the serial recall of digits may not provide an accurate measure of short-term memory in young children.

For this reason, it has been claimed, tasks which involve repetition of single words may be more appropriate than tasks of serial recall with young children (Gathercole, Willis, Baddeley & Emslie, 1994).

2.7.2 Nonword Repetition Test

Several experimental studies of language acquisition have favoured the nonword repetition paradigm. This type of task, it is claimed, may provide a more sensitive measure of phonological memory because there can be no added contribution from a long term lexical store. At the same time, repetition of recently heard speech appears to be a near-automatic response to hearing novel words for many very young children.

In a longitudinal study of 104 four and five year old children, Gathercole and Baddeley (1989) used a nonword repetition task to demonstrate the association between vocabulary knowledge and phonological memory. The significant correlations between receptive vocabulary and phonological memory ($r = .52$ at age five years; $r = .49$ at age six years) prompted the claim that phonological memory plays an important role in vocabulary acquisition.

Although Gathercole and Baddeley (1990a) argue that the opportunity for using long term lexical knowledge is eliminated by employing nonwords, the nonword repetition task (Gathercole et al., 1994) does include words which have prosodic structures with which young children may be familiar. For example, repetition of the non-word *pennel* may, arguably, be supported from contributions such as *pencil* or *tunnel* from long term memory. Snowling, Chiat and Hulme (1991) suggest that the relationship between vocabulary knowledge and nonword repetition is one-way, 'Children with good knowledge of the morphological, phonological, and perhaps particularly the prosodic structure of words will use this knowledge when presented with nonwords to repeat.' (p. 372). This would seem to suggest that sensitivity to the sound structure of speech, arguably phonological awareness, may be inextricably linked with phonological memory.

The relationship between phonological memory and two specific aspects of linguistic ability, perceptual analysis and articulation rate, was investigated in a group of language disordered children with severe deficits in phonological working memory (Gathercole & Baddeley, 1990b). In neither experiment could the acute memory deficits of the language disordered children be attributed to perceptual impediment or difficulties with articulatory output. Nonword repetition, it was concluded from this study, would provide a robust measure of short term phonological memory.

Summary

Significant correlations (r = .55) have been demonstrated between digit span and nonword repetition tasks in studies exploring the phonological loop (Gathercole & Adams, 1993). These correlations were taken to indicate that these two tests are valid measures of phonological memory and may offer further insight into the phonological memory development of children as they begin to read. The next section reviews the literature on the role of phonological memory in the acquisition of vocabulary and reading development.

2.8 Phonological Memory and Language Development

There is now evidence from a number of studies of a significant association between specific areas of language development in young children and phonological memory skill (for example, Gathercole & Baddeley, 1990a; Jorm, 1983). The proposed association between speech rate and phonological memory has been discussed previously in this chapter. This section discusses studies which have investigated the relationship between phonological memory and two other aspects of language development, vocabulary acquisition and reading development.

2.9.1 Vocabulary Acquisition

Evidence from a number of studies suggests that children's vocabulary of 'adult-type' words increases rapidly after the age of 18 months (Nelson, 1973). As significant correlations have been found between vocabulary knowledge and verbal intelligence (for example, Weschler, 1974; Dunn & Dunn, 1982), the cognitive structures which underpin the learning of new words have been the focus of a number of experimental and developmental studies. Evidence that phonological memory plays a significant role in vocabulary acquisition has typically come from studies of language development in young children.

In one large longitudinal study (Gathercole et al., 1992) which began by testing 118 four year old children, significant correlations were found between one measure of phonological memory, nonword repetition, and measures of receptive vocabulary at four years of age ($r = .56$, $p < .001$), at five years of age ($r = .52$, $p < .001$) and at six years of age ($r = .56$, $p < .001$). Gathercole and her colleagues investigated the claim that general verbal ability may enhance performance on nonword repetition tasks (Snowling et al., 1991) discussed previously in this chapter (section 2.2) by performing cross-lagged correlational analysis on the data. The results of these analyses at each wave of the study gave support to the claim that phonological memory plays an important causal role in vocabulary acquisition between the ages of four and five years of age. Beyond the age of five years, however, it was claimed, general verbal ability influenced the development of phonological memory by facilitating the use of analogy between already acquired vocabulary and new words to be learned. Additional support for the specific role of short-term phonological memory in the long-term learning of new vocabulary (Gathercole & Baddeley, 1993), has come from a study of second language learners. In a study of nine year old Finnish children, significant correlations ($r = .66$, $p < .001$) were found between scores on a nonword repetition task and measures of second-language (English) learning some two years later (Service, 1992).

2.9.2 Reading Development

In reading, Baddeley (1986) suggests, the two elements of the phonological loop work together: the articulatory rehearsal system is responsible for converting the written material into a phonological code before it is registered in the phonological store.

Although the association between literacy and memory has been investigated in a number of studies, there is still little understanding of the exact nature of the relationship. Most studies which have investigated the relationship between memory span and reading have worked with groups of children who are poor readers and have cited deficits in phonological memory as causal to reading failure (for example, Liberman et al., 1977; Liberman & Shankweiler, 1979; Mann & Liberman, 1984).

In one study (Mann & Liberman, 1984) 62 children were asked to recall lists of phonologically similar letters, for example "b','c','d','g' and phonologically dissimilar letters, for example 'w','k','q','h'. One year later the children were allocated to three groups based on reading ability, 'good', 'average' or 'poor' readers. Although the better readers had overall better recall, this group was found to include children who had been more sensitive to the phonological similarity of the letters in the earlier memory task. As there was no evidence of the phonological similarity effect in the group of poor readers, these findings were taken to indicate that poor readers may not use phonological strategies for recall. From these results, phonological memory was claimed to have a causal role in reading development. However, as no initial measures were taken of reading, it could be argued that the early reading ability of some children had influenced scores on the early memory task and subsequent reading achievement.

Findings from a three year study of 40 five year old children (Ellis & Large, 1988), concur with this alternative view of causal direction. The results from this study suggested that at the preliminary stage of assessment (age five years), early reading development stimulated phonological memory. However, from the measures taken a year later, the relationship would appear to become reciprocal. Conclusions from this study are therefore not clear cut: the influence of reading on the development of phonological memory skill would appear to have been claimed from cross-lagged correlations between reading and only one measure of phonological memory (auditory digit span). The correlations between reading and the other measures of phonological memory in this study (auditory word span and auditory sentence span) would seem to indicate a converse causal relationship where reading may have been a beneficiary of early memory skill. Again, the relationship between phonological memory and reading is not clear as the children in this sample were all reading at the initial stage of testing. It would seem feasible that the true contribution of phonological memory to reading development can only be investigated by assessing children at a preliterate stage of development.

From the literature, it would appear that one study has monitored reading and phonological memory development from a preliterate stage (Gathercole & Baddeley, 1993b). From an original sample of over 100 children, 70 four year olds were found to be non-readers at the start of the study. A series of reading tests was administered to this group some four years later and the phonological memory measure, nonword repetition, was found to be a significant predictor of subsequent reading performance on only one measure of reading ability, the Primary Reading test (France, 1981). These findings prompted the claim that deficits in phonological memory may prevent the 'blending' strategy required for phonological recoding of unfamiliar words or, in line with the previous section, that deficient phonological memory skill may prevent the long-term learning of grapheme-phoneme associations (Gathercole & Baddeley, 1993a).

Summary

This chapter has reviewed a number of studies which have suggested that although young children are capable of engaging in subvocal rehearsal, they rely on modality dependent codes for processing information in working memory, using a predominantly visual strategy until sometime after the age of five years (Gathercole & Baddeley, 1993a). However, there is as yet no conclusive evidence why the shift from a visual strategy to a phonological strategy occurs around this age. One suggestion is that as children begin to read and become familiar with the process of recoding visual stimuli (graphemes) into speech-based codes (phonemes), this use of phonological coding becomes generalised to memory tasks (Longoni & Scalisi, 1994). Some support for this theory comes from a cross-linguistic study which reports evidence of a significant phonemic similarity effect with visually presented stimuli in six year Italian children as they began to read during their first year of formal schooling (Venneri, Nichelli, Cubelli, Corrado, & Cossu, 1991).

Despite a further suggestion that children begin to employ subvocal rehearsal as they become proficient at silent reading (Gathercole & Baddeley, 1993b), it has been claimed that insufficient attention has been paid to the possible causal role of learning to read in the development of phonological coding skills in working memory (Wagner & Torgesen 1987). Wagner and Torgesen (1987) therefore warn ' ... it is no longer enough to ask whether phonological skills play a causal role in the acquisition of reading skills, or even whether learning to read plays a causal role in the development of phonological skills' (p. 209). They therefore recommend that attention should be given to which aspects of phonological processing, phonological awareness or phonological memory, are causally related to which aspects of reading.

CHAPTER 3

RATIONALE FOR THE STUDY

Introduction and Outline of Chapter

Phonological processing refers to the use of information which is based on the sound structure of spoken language, or phonological information, to process speech or written language. Academic interest in the role of speech-based processing has stimulated a large body of research by cognitive, developmental and educational psychologists into one specific area of language, the acquisition of literacy. The literature review (Chapter 1 and Chapter 2) has argued that studies of the two phonological processing skills most commonly associated with 'normal' reading development, phonological awareness and phonological memory, have to date been undertaken in comparative isolation of each other. This chapter outlines the rationale, the aims and the design of a study which would aim to incorporate the two areas of research. These are discussed under the following headings:

- phonological processing
- the Phonological Deficit Hypothesis
- the aims of the study
- the research design
- the research sample
- the test battery
- summary

3.1. Phonological Processing

From the literature it would appear that studies of phonological awareness have provided a major part of the research evidence on phonological processing. With adequately developed phonological awareness, it has been suggested, a child is able to understand that an alphabetic orthography is the written correspondent of spoken language (Mattingly, 1980; 1991). There is considerable evidence also that the alphabetic principle, or the presumed interaction between phonological awareness and alphabetic knowledge, is an important factor in learning to read (Byrne & Fielding-Barnsley, 1990). Research findings suggest that it is through an awareness of the individual sounds or phonemes of spoken language, that the child is able to segment letter strings into phoneme-based units and, by blending the phonemes together, to read (Blatchford & Plewis, 1990).

Findings from a range of separate studies have proposed that individual differences in reading ability may be related to the efficiency of phonological memory. Phonological memory, it has been reported, is responsible for the translation of the written word into a sound-based or phonological code which can then be used to retrieve the appropriate meaning from long term memory (Wagner & Torgesen, 1987; 1993). Baddeley (1986) suggests that phonological memory plays an important role in the translation of a written word into its component sounds and the subsequent short term storage of these individual sounds. If this short term storage functions efficiently, then additional cognitive resources become available to facilitate the difficult task of blending individual sounds together to make a single 'word'. From the literature, this 'phonetic recoding' strategy plays a vital role in early reading (Ehri, 1995).

The reading models discussed earlier (Chapter 1) all include a stage at which phonological processing ability is considered to be very salient. The reviews in Chapter 1 and Chapter 2 have shown there is now good evidence from studies of 'normal' readers that these phonological processes are involved from the earliest stages of learning to read (Ehri & Wilce, 1985; Stuart & Coltheart, 1988). Other studies of 'non-normal' or dyslexic readers have, also made a significant contribution to academic understanding of the critical importance of phonological processing during the acquisition of literacy.

3.2 The Phonological Deficit Hypothesis

From studies of children who are experiencing specific difficulties with literacy skills (dyslexia) has come the hypothesis that deficits in the processing of phonological information underpin this acute form of 'reading failure' (Hulme & Snowling, 1992; Stanovich & Siegel, 1994). In addition, some current research in dyslexia suggests that these acute difficulties with literacy may reflect deficits in the maturation of the child's phonological system (Nittrouer & Studdert-Kennedy, 1987; Stackhouse & Wells, 1992). In normal language development, underlying phonological representations, or patterns of speech sounds, are gradually refined. This refinement is thought to herald increases in both speech rate and verbal short-term memory (Snowling & Hulme, 1994). Full maturation of the phonological system, normally complete by about the age of five years, would therefore seem crucial to reading an alphabetic script which demands mapping written letters to the sounds they represent (Ehri; 1995; Frith, 1985). As Snowling (1995) suggests, 'If these phonological representations are not well-specified at school entry, then the child may not be ready to benefit from reading instruction' (p. 136).

Studies of dyslexic readers have consistently reported poor performance on a range of phonological processing tasks such as phonological awareness (Manis, Custodio & Szeszulski, 1993); digit span (Torgeson, Rashotte, Greenstein, Houck & Portes, 1988); speech production (Scarborough, 1990); non-word repetition (Snowling, 1981); and non-word reading (Rack, Snowling & Olson, 1992). These tasks may all be said to assess underlying phonological processing. One recent study of dyslexic readers (Rack, Hulme, Snowling & Wightman, 1994) has proposed that different degrees of phonological deficit may affect reading development at different stages. Results from the study identified children who were able use phonetic cues to read but were unable to progress to a stage of using full grapheme-phoneme associations and sound blending. By extension, it is commonly agreed that children who are phonologically deficient may encounter difficulties from the earliest stages of learning to read.

It would seem to be the case that a battery of tests which aimed to assess components identified in the proposed 'Phonological Deficit' hypothesis at a preliterate stage could provide a useful predictive measure of children who may experience difficulty in reading. As Gathercole and Adams (1993) state,

> Reliable assessment ... before children start school could therefore provide an invaluable means of assessing whether children are at risk of encountering persistent language problems at an early stage at which remedial intervention would be maximally effective. (p. 770)

3.3 The Aims of the Study

Despite the apparent importance of phonological awareness and phonological memory to reading development, the two main bodies of research appear to have developed in parallel rather than in partnership. As a result, there is little understanding of whether phonological awareness and phonological memory are measures of one unitary processing skill. Whether they make common or dissociable contributions to reading, particularly at the earliest stages of development, would appear to be an important issue in constructing a phonological assessment tool which could serve to identify children at the preliterate stage who may be destined to experience difficulty in learning to read. This issue, it has been suggested, can only be clarified by a 'direct empirical evaluation of the longitudinal contribution of these two phonological processing skills to literacy acquisition' (Gathercole & Baddeley, 1993b, p. 269).

The major aim of this study was therefore to evaluate the developmental relationship between the two phonological processing skills, phonological awareness and phonological memory, and their contribution to the acquisition of literacy. The research questions were therefore

- What is the relationship between phonological awareness and phonological memory at a preliterate stage?
- What are the relative contributions of these two phonological processing skills to the acquisition of the alphabetic principle and subsequent literacy?

There is still considerable debate whether measures of general intelligence are relevant to the assessment of specific difficulties with literacy. Current definitions of dyslexia typically involve a 'discrepancy' assessment where a significant difference is found between a child's reading ability and general intelligence. The debate has in part arisen from accumulating evidence that children who experience this acute difficulty in learning to read and spell do not differ qualitatively from other 'garden variety poor readers' who are positioned at the lower end of the continuum of reading ability (Siegel, 1988; Stanovich, 1994). Conversely, it has been suggested, the degree to which a dyslexic child's phonological deficit impairs his or her reading development is dependent on the other skills he or she has available (Rack, Snowling & Olson, 1992). Arguably, these 'other skills' could include general intelligence. By taking a preliterate measure of general cognitive ability and assessing the contribution made by general intelligence to early reading development, it may be possible to contribute to this debate.

Most importantly, however, the literature review has highlighted the identification of a group of phonological processing skills which, although outside the domain of reading, impact directly on reading development and can be assessed before the child begins to learn to read or begins to experience reading failure.

3.4 The Research Design

As Manstead and Semin (1988) insist, the design of a study is crucial to translating research questions into real projects. This section discusses the theoretic strategies and practical issues considered in the design of the present study.

There is now a sizeable body of research which has contributed significantly to the understanding of how children learn to read. However, there is still considerable debate regarding which methodologies appear to be the most efficient in identifying factors which may be causally related to reading development. Stanovich (1993) refers to the 'methodological thicket' (p. 228) of designs which appear throughout the literature on causation studies. From the literature review, five research designs appear to dominate studies of phonological processing and reading development: comparative studies, training studies, correlational studies, cross-sectional studies and longitudinal studies.

Several studies (for example, Bradley & Bryant, 1978; Shankweiler, Liberman, Mark, Fowler & Fischer, 1979) have compared the performance of good and poor readers, in an attempt to identify the underlying skills, such as phonological awareness or phonological memory, which may be critical in learning to read. However, evidence from such studies can neither determine causality nor discount the possibility that the assessed skill is enhanced by the ability to read: the poor readers' low scores may therefore be unsurprising. It may also be the case that results in these studies are influenced by another unknown variable, such as general intelligence. Training studies have most typically been used to address these issues.

Training, or experimental designs, assume that training directly affects a target skill (the independent variable) which may be expected to influence subsequent reading (the dependent variable). The experimental training design has been most commonly used in studies which set out to confirm the direction of causality (for example Bryant & Bradley, 1985; Hatcher et al., 1994). However, by default, studies of this type can sometimes spuriously assume that the target skill can be trained and also that the cause-effect relationship observed does actually exist outside the 'artificial world' of the experimental design.

The disadvantages of studies which employ a correlational design have been discussed earlier (see Chapter 1.7.1). Yet, correlational studies have provided useful data on the relationship between reading ability and other cognitive skills. For example, valuable evidence which suggests that the association between reading and general intelligence, or between reading and vocabulary knowledge, strengthens as children learn to read has been reported from the analysis of correlational data (Stanovich, Cunningham & Feeman, 1984b; Gathercole, Willis, Emslie & Baddeley, 1991). However, it should be noted, these two studies also incorporated a longitudinal design where variables were repeatedly measured as reading developed; this method has been used to some effect in assessing whether preliterate phonological awareness has a direct effect on subsequent reading ability (for example, Bradley & Bryant, 1983). A number of developmental correlational studies have also compared the performance of different groups by using cross-sectional surveys (for example, Bradley & Bryant, 1978).

Cross-sectional studies have provided valuable insight into the development of phonological awareness or phonological memory typically by taking 'snapshots' of a group of children drawn from two or more age ranges at a particular point in time (for example, Stanovich et al., 1984b; Henry, 1991a). Studies of this type can offer immediate information and, because of their 'once-off' nature, a larger sample size is often more readily available. The association between phonological memory and awareness of rhyme in children of five and six years of age has been previously investigated using this design approach (Gathercole, Willis & Baddeley, 1991). However, Ellis and Large (1988) warn that cross-sectional studies ...

> ... which compare different groups of people at different stages of acquisition must always come a poor second when small but reliable changes with age are to be detected ... and where we do not wish to make the false assumption that the abilities of a younger cross section were necessarily present in the older cross-section at a previous time. (p. 48)

The final design commonly cited in studies of phonological awareness or phonological memory and reading development is that of the longitudinal study. Cohen and Manion (1992) suggest this research design is especially suited to educational research because of its unique ability to identify typical patterns of development within the selected sample. The review in Chapter 1 and Chapter 2 reported on several longitudinal correlational studies which have taken measures of the targeted phonological processing skill, phonological awareness or phonological memory, and reading from the same sample of children over a period of time (for example, Bradley & Bryant, 1983; Stuart & Coltheart, 1988; Gathercole & Baddeley, 1993b).

If a clearer understanding of the specific nature of phonological processing is to be gained then, Wagner and Torgesen (1987) believe, it is necessary to give 'a relatively large number of children tasks that measure each of the (two) kinds of phonological processing, ideally on several occasions over the course of their early development of phonological skills.' (p. 208). Studies of this type, it has also been suggested, should include at least two assessment points 'separated by a considerable period of time' (Gathercole & Baddeley, 1993a, p. 117).

A longitudinal study was therefore designed to address the proposed research questions. Three assessment points were planned over an 18 month period. The first assessment point was when the children were all still at a preliterate stage before full time formal schooling began. The second assessment point was six months later after the children had been in school for one term and the final assessment point was at the end of the first year in school.

The second consideration of the study design was identifying those who would be participants in the research: the sample.

3.5 The Research Sample

The dependability of a research project, it has been said, is crucially affected by the principles or system used to select its participants (Robson, 1995).

3.5.1 The Target Population

The literature review has clearly indicated that to date there has been considerably less systematic investigation of phonological working memory than of phonological awareness in preliterate children. Moreover, clear conclusions from several studies have been prevented by the inclusion of samples which have indiscriminately mixed non-readers and children who may be just beginning to read (for example, Alegria et al., 1982; Tunmer & Nesdale, 1985).

Two studies which have investigated the relationship between phonological memory and reading development have proposed differing causal associations. The first study assessed the memory skills of 62 kindergarten children and then assessed their reading ability one year later (Mann & Liberman, 1984). Results from the study indicate that the earlier memory measures were effective predictors of subsequent reading ability. However, this claim that phonological memory has a causal role in the acquisition of reading must be treated with caution as no assessment was made of reading ability in kindergarten. Therefore, it could be argued, some of the children may have already been reading and the direction of causality may have been the reverse of that claimed by the authors.

This possibility, that reading ability enhances phonological memory, is reinforced by findings from another study (Ellis & Large, 1988). In this study, by calculating cross-lagged correlations, a stronger correlation was reported between reading at age five years and memory span at age six years than between memory span at age five years and reading at age six years. The data from this study are again however confounded by the inclusion of some children who could already read.

Similarly, evidence from some studies of a strong association between phonological awareness in kindergarten and later reading ability must be carefully considered as these samples have often included some children who were already reading. An example of this would be the study carried out by Lundberg and his colleagues (Lundberg, Oloffson & Wall, 1980). As it assessed a very broad range of skills, the study was reported to have made a unique contribution to academic understanding of the nature of phonological awareness and its causal role in reading development. However, Lundberg's conclusions were disputed by a later re-analysis of the same data (Wagner & Torgesen, 1987). In the re-analysis, partial correlations were calculated between performance on the kindergarten phonological awareness tasks and subsequent reading with the measures for kindergarten reading ability held constant. As a result and in contrast to the significant correlations proposed by the original study (Lundberg et al., 1980), Wagner and Torgesen found only two of the nine partial correlations to be significant and suggested that the observed variance in reading achievement at Grade 1 may be attributed to differences in reading skill at the outset rather than phonological awareness.

One effective way of discriminating between these two causal hypotheses and simultaneously monitoring the relationship between phonological awareness and phonological memory would be to assess these two skills in a group of children who were initially all unable to read. Selecting a group of pre-school children at random would not necessarily guarantee a totally preliterate sample and an alternative sampling technique was needed.

3.5.2 The Sampling Design

In order to answer the research questions for this study, certain criteria had to be met. First, it was important that all the children were at a preliterate stage. Second, these children should be representative of a preliterate population shortly before entry to formal schooling. In order to ensure the children in the sample were statistically representative of the population, quota sampling was considered to be the most appropriate technique. Quota sampling ensures that various elements of a population are represented usually in the relative proportions in which they occur in the main population. This study therefore recruited a group of preliterate children within a given age range. There were equal numbers of boys and girls who were representative of a range of abilities and of mixed socio-economic status. The other criteria were that the first language should be English and that no child undergoing statementing procedures or with a speech or language difficulty could be included.

3.5.3 The Sample Size

In order to draw meaningful conclusions from any data collected, the number of subjects was a particularly important consideration. If an insufficient sample size is chosen, significant effects in the data may be overlooked in the analysis. Rudestam and Newton (1992) recommend the use of power analysis to identify the optimum sample size. Power analysis defines the optimum number of subjects taking account of the significance level of the study, the size of the effect of the independent variables and the type of statistical procedures to be used. For this analysis generally accepted levels of significance and power were used: a significance level of .05 and a power level of .80. If only two independent variables, phonological awareness and phonological memory, were to be tested, the power analysis recommended a sample minimum of 52 children. However, as a number of skills were to be measured in a multivariate framework, more subjects were advisable (Lipsey, 1989).

A major consideration in any study of longitudinal design is that of subject attrition. The review in Chapter 1 and Chapter 2 of other longitudinal studies of very young children (for example, Stuart & Coltheart, 1988; Gathercole & Adams, 1994) suggested that a substantial number of the children available at the first assessment point were no longer available for subsequent assessments. Based on the numbers reported from these two studies, it was predicted that up to twenty five per cent (25%) of the sample may be lost over the 18 month duration of the study. Before finalising the sample size, consideration had also to be given to the influence sample size may have on the type of statistical procedure which could be used to analyse the data once it has been collected.

3.5.4 The Sample and Statistical Analyses

For most data, a number of analytical strategies may be appropriate. Robson (1993) insists that identification and selection of suitable procedures should however be integral to the design stage of the research, not least because this can influence decisions regarding the size of the sample. At the design stage, several forms of analysis were considered to be appropriate for this study.

Causal associations have frequently been claimed by assessing the strength of the correlations between the proposed causal cognitive skill and subsequent reading (for example, Gathercole & Baddeley, 1993b; Tunmer, Herriman & Nesdale, 1988). High correlations in such studies have led to claims that a particular skill may be critical to reading development. The longitudinal design of this study would also facilitate cross-lagged correlational analysis which has been employed in previous studies to support causal hypotheses (for example, Ellis & Large, 1988).

Evidence from other studies reviewed in Chapter 1 (for example, Muter, 1994) suggested that, although interval scale measures were to be used in the study, some data from the first assessment point may not fully meet all the criteria for parametric analysis and transformed scores may be required. Where appropriate, descriptive measures of central tendency would also be reported. From the literature review, it was anticipated most scores would begin to show a pattern of normal distribution by the final stage of testing.

Based on the findings of the studies reviewed earlier (Chapter 1 and Chapter 2), high correlations between some of the variables, or multicollinearity, were also anticipated. When high inter-correlations are observed, factor analysis is a useful tool for measuring how the individual variables cluster together. This procedure has been used previously in a number of studies to try and identify which variables may be presumed to be measuring the same underlying construct or skill (for example, Yopp, 1988; Gathercole et al., 1991). Walsh (1990) suggests two basic 'rules of thumb' for the identification of valid factors. First, each factor must account for more of the variance than could be accounted for by just one variable and should therefore have an eigenvalue of more than one (eigenvalue >1). Second, there should be at least three variables per factor. Once identified, the factors must be named which, according to Walsh (1990) 'requires insight and theoretical knowledge' (p. 337). While factor analysis can suggest that a significant association exists between a set of variables, it cannot identify the unique contribution of each or even propose any causal relationship between them.

To predict the value of one variable from the known value of another variable, a regression procedure is required. Pehazur (1982) suggests that regression analyses are indispensable in any form of scientific research, 'The regression model is most directly

and intimately related to the primary goals of scientific inquiry: explanation and prediction of phenomena.' (p. 42).
Multiple regression techniques have been employed in a range of complex correlational studies to test the contribution of a particular cognitive skill to the variance in an outcome reading measure (for example, McDougall et al., 1994; Stuart, 1995). Extreme cases, or outliers, can influence the regression solution but at the same time can be important indicators that the distribution of scores for a particular variable is more extreme in the population being studied than would be expected normally. Rather than deleting such cases, Tabachnick and Fiddell (1989) recommend that these scores should be transformed using a logarithmic transformation procedure prior to analysis. In order to make sensible use of a multiple regression technique, however, the case-to-independent variable ratio has to be substantial. Tabachnick and Fiddell (1989) recommend a minimum ratio of 5:1 (case to independent variable) with a higher ratio if the outcome measure is not normally distributed.

An advanced form of the multiple regression procedure which is less common in the literature is that of 'statistical modelling' (Breakwell, 1994) or causal path analysis. In path analysis, causality can be tentatively examined by computing a series of multiple regressions and entering the resulting beta coefficients on a path model. Path analysis is reported to be preferable to factor analysis as 'this process encourages the production and testing of true models of psychological phenomena, rather than mere 'shopping lists of variables' (Bramwell, 1996, p. 77). As path analysis requires the researcher to first map out the proposed causal path, theoretic understanding of the data and a clear knowledge of background theory would seem crucial. The comparatively limited evidence in the literature of this procedure, Bramwell contends, may in part be because 'larger sample sizes are required, and longitudinal data may be desirable, both of which add to the cost of the research' (p. 67). One longitudinal study which aimed to identify causal relationships between short-term memory, phonological processing and reading, in a group of children aged between five and seven years, failed to recruit a sample of non-readers large enough to facilitate path analysis (Ellis, 1990). Of the 40 five year old children recruited to the study, only eight were found to be non-readers and the author reported the small sample size did not permit 'powerful causal path modelling ' (p. 111). Despite the range of predictor skills assessed, the size of the sample led the author to add,

> At best we can use correlational techniques to see which of the 44 abilities assessed in pre-reading 5 year olds predicted their reading abilities one year later and the small sample size dictates (i) the analyses are very conservative and (ii) the conclusion must be viewed as tentative until there is a replication with much larger N. (p. 111)

Based on the results of the power analysis (Rudestam & Newton, 1992) a minimum sample of 52 would have been adequate for the study. However, for the projected regression analyses involving up to six independent variables and the possibility of non-normally distributed outcome measures, a sample size of 60 was considered more appropriate. In order to compensate for possible attrition of up to 25% over the duration of the study, a sample size of 80 children was considered to be the most appropriate.

3.5.5 <u>Location of the Sample</u>

From the literature, it would appear a number of previous studies of young children have taken place in nursery schools (for example Bradley & Bryant, 1983; 1985). As a result, studies of nursery-age children may have tended to favour middle-class children because of the relative accessibility of nursery schools which hitherto have catered for a particular socio-economic group (Dowker, personal conversation, 22.11.95). One possible solution would have been to recruit a sample of children who were not in any form of pre-school provision. However, as Bramwell (1996) concluded, all research is bound by practical limits. Robson (1993) outlines these practical limits as 'realities' of research in terms of sample size,

> The exigencies of carrying out real world studies can mean that the requirements for representative sampling are very difficult, if not impossible, to fulfil. (p. 42)

Despite the many strengths of their design, longitudinal studies are particularly demanding of research resources. For this study it was necessary to ensure that testing locations were accessible, familiar to the children and could guarantee a quiet environment for each assessment session. The study was therefore carried out in eight pre-school centres. Following discussions with the pre-school advisers from two neighbouring local education authorities, these eight centres were thought to represent a broad socio-economic range.

Five of the centres were selected to participate in a pilot study. For the pilot study, the Headteachers of the pre-school centres (nurseries, nursery classes and playgroups) were asked to nominate six children, three girls and three boys. For the pilot study there was therefore a sample size of 30 children.

For the main study, the Headteachers of all eight pre-school centres were each asked to nominate ten children, five girls and five boys, who had not participated in the pilot study. The Headteachers were asked to select children they considered to be representative of the full ability range but who were also unable to read. As discussed previously (para 3.5.2) children who had already been identified for specialist help or statementing procedures were excluded. The sample size for the main study was 80 children.

All research demands adherence to sensible ethical standards. Sommer and Sommer (1991) insist that 'Researchers who study vulnerable populations such as children ... have special responsibilities in terms of protecting human subjects' (p. 19).

Prior to the commencement of the study, written permission was sought first from the Chief Education Officers in the two local education authorities targeted for the study. Once permission was received, the individual nurseries, nursery classes and playgroups were approached and written permission was requested from the parents or adult carers of each child included in the study. Permission from the Headteachers of the 27 infant schools which participated in the follow-up sessions was obtained in a similar way. On each occasion, the children were assessed in the familiar environment of their own nursery or school.

3.6 Selecting a Test Battery

In longitudinal studies, selection of the test battery is particularly important. As Gathercole and Baddeley (1993a) warn '... there is no going back in a longitudinal study: By the time the first wave of testing is completed, it is too late to realise that a critical control measure is missing' (p. 117). However, some parsimony was required in the selection of tests to ensure that all were relevant to the research questions and that the battery length was practicable for the children it aimed to assess. The literature review, reported in Chapter 1 and Chapter 2, had indicated a number of tasks which would seem appropriate for assessing phonological awareness and phonological memory skill in very young children.

Summary

This chapter began by summarising the review of literature on phonological awareness and phonological memory. The resulting research questions were presented together with the theoretic and practical considerations which underpinned the design of the study. To address the research questions, a longitudinal study with three assessment points over an 18 month period was undertaken. A quota sampling methodology was used to select the sample of 80 preliterate children who were monitored from a pre-school stage through the first year of formal schooling.

The literature review had revealed a number of theoretic issues for consideration in designing a study of very young children. It was therefore, as Sommer and Sommer (1991) note 'essential to run a pilot study in order to be sure that the equipment is working and that directions are easily understood.' (p. 92). The next chapter reports on the design of and data collected during the pilot study.

CHAPTER 4

THE PILOT STUDY

Introduction and Outline of Chapter

The literature review in Chapter 1 and Chapter 2 has discussed studies which have investigated the relationship between phonological awareness and reading (for example, Bryant & Bradley, 1983; Hatcher et al., 1994), or the relationship between phonological memory and reading (for example, McDougall et al., 1994). There appears, however, to have been little systematic investigation of the relationship between these two phonological processing skills and their contribution to subsequent literacy.

A longitudinal study was therefore designed to address these issues. The first aim of the study was to assess phonological awareness and phonological memory in a group of young children before they learned to read. The second aim of the study was to monitor and assess the relative contribution of these two phonological processing skills in the same group of children over the next year as they began to read. A final aim was to assess the contribution of phonological processing to the acquisition of the alphabetic principle.

This chapter discusses the development, pilot testing and design of the assessment battery under the following headings:

- methodology of the pilot study
- results
- discussion
- summary

4.1 Methodology of the Pilot Study

From the literature review of phonological awareness (Chapter 1) and phonological memory (Chapter 2), there appeared to be only one cross-sectional study which had investigated the relationship between these two processing skills in a group of young children, some of whom were reported to be non-readers (Gathercole et al., 1991).

4.1.1 Aims

Identification of different patterns of relationship between the various measures of phonological awareness and subsequent reading has prompted the claim that phonological awareness may be heterogeneous (Bryant et al., 1990). In an attempt to clarify the situation, Treiman and Zukowski (1991) have argued for two separate components of phonological awareness: the linguistic and the cognitive components.

From the linguistic viewpoint, 'phonological awareness' has been found to reflect sensitivity to spoken language at the syllabic, at the intra-syllabic (onset and rime) or at the phonemic (single sound) levels. Data from several longitudinal studies have proposed that phonological awareness is developmental with sensitivity to syllables preceding awareness at the intra-syllabic level, and intra-syllabic awareness preceding sensitivity at the single-sound or phonemic level (for example, Muter et al., 1994).

Assessments from a range of tasks have proposed preliterate rhyming ability to be predictive of later reading achievement (Bradley & Bryant, 1983). Other findings that phonemic awareness develops later, often after the child has begun to read, have not only prompted the suggestion that phonological awareness arises as a consequence of learning to read (Morais et al., 1979) but also that assessment at the phonemic level may be inappropriate for children who are at a preliterate stage of development (Bryant et al., 1990).

From the second, cognitive, perspective there appears to be a wide variation between studies in the cognitive demands of the tasks employed. There is some evidence that simple awareness of the phonological structure of language is implicit and precedes the more explicit ability to manipulate these sounds (Treiman & Zukowski, 1991). It has also been argued that tasks which demand phoneme transposition or deletion (Muter et al., 1994) may be too difficult for children before the age of seven years.

Studies of the association between phonological memory and reading acquisition have typically focused on the span deficits of poor readers (for example, McDougall et al., 1994). However, it has been suggested that digit span and word repetition are lexically based tasks which reflect familiarity with the stimulus items rather than short term memory processes (Hulme et al., 1991). A test of nonword repetition, it has been argued, may provide a more sensitive measure of immediate phonological memory skill as no contribution is available from long term memory (Gathercole et al., 1994b). Nonword repetition is also reported to be particularly suited to the innate imitative language tendencies of very young children (Gathercole et al., 1994b).

The speed at which information held in the phonological store can be rehearsed subvocally is thought to be the principal source of developmental change in memory span (Gathercole & Baddeley, 1993a). Despite some evidence that sub-vocal articulation rate may correlate directly with actual speech rate in adults (Hulme et al., 1984), it would appear that no significant association has to date been established between speech rate and memory span in children at a preliterate stage (Gathercole & Adams, 1994).

Based on the evidence in the literature, a battery of tests was designed to investigate the relationship between phonological awareness and phonological memory in preliterate children and the contribution of these two phonological processes to subsequent literacy.

The pilot study was carried out with a small sample of preliterate children to investigate whether the battery designed for the first stage of testing could be appropriately used.

4.1.2 Construction of the Tests

Despite claims for an association between phonological awareness and subsequent reading, the strength and causal direction of the association is still unclear. The review in Chapter 1 concluded that direct comparison between studies has been impeded by inconsistent task descriptions and methodologies. There was also noted to be a lack of data on test reliability and validity. A series of tests, modelled on those used in previous studies, was constructed. The pilot study aimed to assess the reliability and validity of these measures of phonological awareness.

General Language Ability

The review of phonological awareness tests in Chapter 1 had identified a wide variability in the administration and cognitive demands of the tasks. A workbook was therefore designed to assess whether pre-readers as young as four years of age would understand the terminology most commonly used in phonological awareness tasks, for example, *first, different, same.* The format of the workbook was modelled on a standardised measure, the Boehm Concept Development Test (Boehm, 1986) which purports to assess the relatively abstract ideas required in the early stages of maths, reading and science learning. For the pilot study, the child listened to oral instructions and marked the workbook accordingly; for example the child was asked to 'Put a cross on the *first* house' or 'Put a cross on the bucket which is *different*' or 'Put a cross on the boxes which are the *same*'.

The literature review had also revealed a number of studies where a significant correlation had been found between a pre-school ability to write in an alphabetic code and subsequent literacy achievement (for example, Riley, 1994). Each child was asked to draw a picture of his or her teacher and to write his or her name below. This was considered to be a 'normal' nursery experience for children of this age and would be useful as an introductory confidence-building task. The experimenter also completed the task at the same time as each child and was therefore unable to offer assistance to any of the children. The child was awarded one mark for each letter written which was to be found in his or her name. Clearly, using this method for scoring, the child with a longer name (for example, *Charlotte* with a maximum of nine letters), had some advantage over the child with a shorter name (for example, *Tom* with a maximum of three letters). The marks were therefore converted to a percentage score where the child's complete name represented 100%.

Tests of Phonological Awareness

The review of the literature had indicated that phonological awareness may be both heterogeneous and developmental. A set of tasks was designed in game-format which would be sensitive to the levels of phonological awareness previously found to be measurable in young, preliterate children. Three tests of phonological awareness were designed and were played with a large knitted doll, *Mr Buttercup.*

Rhyme detection

This task was modelled on an earlier test of rhyme oddity (Bradley & Bryant, 1983). A set of coloured picture cards was used which depicted thirty objects selected from an age-appropriate corpus of spoken vocabulary (Raban, 1988; Walley & Metsala, 1992). These cards had been spontaneously recognised in an earlier pilot study where 20 four-year old children had been asked 'What can you see in this picture?' For the rhyme detection test there were four practice items followed by ten experimental items. For each item the child was shown three pictures (for example, *hat*, <u>*bed*</u>, *cat*) and asked to identify the 'odd-man-out' for *Mr Buttercup.*

Rhyme production

This task was also modelled on an earlier version (Stuart & Coltheart, 1988). A set of coloured picture cards which depicted 14 objects familiar to four year old children, for example *tree* and *cow* was designed and trialled as previously. As a pre-task activity for the rhyme production test, the child was asked to finish the second line of *Jack and Jill* in order to introduce the concept of 'rhyme'. The task itself included four practice items and ten experimental items. For the practice items, the child invited *Mr Buttercup* to volunteer an alternative response. For the experimental items, the child was shown each picture individually and asked to generate another word, real or make-believe, which 'sounded the same at the end'.

Alliteration

This test, was modelled on the 'Segment Initial Phoneme' task employed by Stuart and Coltheart (1988). A series of coloured picture cards was designed, depicting objects from the same age-appropriate corpus of spoken vocabulary for example *cow/cat; duck/dog.* These illustrations had also been trialled earlier with a group of four year old children. There were three practice items followed by ten experimental items. For each item, the child was shown four picture cards and asked to eliminate first the semantic distracter (for example, *table, television, bed,* *tiger*) and then the phonemic 'odd-man-out' (for example, *table, television,* *bed*). For the practice items, *Mr Buttercup* volunteered responses and explanations.

Tests of Alphabetic Knowledge

It has been suggested that phonological memory contributes to long-term learning of letter-sound associations (Gathercole & Baddeley, 1993a) and that early letter-name or letter-sound knowledge may predict subsequent reading ability (Blatchford & Plewis, 1990; Bradley & Bryant, 1983; Share et al., 1984; Stuart & Coltheart, 1988). In these earlier studies, alphabetic knowledge has generally been presented in one mode; typically, the child has been shown the written symbol (grapheme) and asked to supply either the corresponding name or sound (phoneme).

A more recent study employed an additional mode of presentation by assessing children's ability to identify an appropriate grapheme in response to a spoken letter name or sound (Huxford, 1993). Reporting a clear distinction in scores between the original 'visual' mode and the additional 'auditory' mode of presentation, Huxford (1993) suggested that,

> children's letter-name scores when offered an aural stimulus were so much higher than when offered a visual stimulus that the experimenter doubted that some children fully understood the latter task despite careful rephrasing of the requests and use of examples. (p. 190)

It could be argued that this discrepancy resulted from methodological differences: in the aural modality the child was required to selected from an array of graphemes, whereas in the visual condition the child was presented with a single grapheme. Higher scores in the aural presentation condition could therefore, in part, be attributed to chance.

Four tests of alphabetic awareness were therefore constructed: two employed visual presentation and two employed aural presentation. The 5 cm high lower case letters were printed on 26 individual cards. The order of presentation was based on findings from two earlier studies discussed in Chapter 1 (Huxford, 1993; Stuart, 1987). The same order was used to assess both letter-name and letter-sound knowledge. Based on the findings of previous studies (for example, Stuart & Coltheart, 1988), low scores were anticipated in this sample of pre-schoolers.

Aural tests of alphabetic knowledge

For this task, the child was asked to identify the symbol (grapheme) which matched the letter-name or letter-sound spoken by the experimenter.

Visual tests of alphabetic knowledge

For this task, the child was asked to give the letter-name or letter-sound which matched the printed symbol indicated by the experimenter.

Instruction in Alphabetic Knowledge

In order to investigate whether the teaching of alphabetic knowledge is considered a priority or whether, as has been previously suggested, explicit teaching of the alphabet has been displaced by contemporary models of reading instruction (Stuart, 1995a), two questionnaires were designed. Examples are shown at Appendix B and Appendix C. In the main study, the first would be sent to the staff in the pre-school centres and the second would be sent to the reception class teachers once the children entered full-time schooling. For the pilot study, the first questionnaire was given to the twelve participating pre-school staff and the second questionnaire was sent to fifteen reception class teachers in a neighbouring county who would not be participants in the main study.

Both questionnaires asked the staff to identify any pre-reading skills which they considered to be important to the child prior to full time schooling. The second questionnaire asked the reception class teachers to list which approaches they used for reading instruction and which resources (for example, television programmes or classroom-aids) they used to support their teaching.

Test of speech rate

This test was included to investigate the proposed relationship between speech rate and memory span (Hulme, 1984). For this task, the child was asked to give three rapid repetitions of the stimulus word or words spoken by the experimenter. Measures for the three items were taken using a Macintosh Powerbook 540C with SoundEdit software. Earlier pilot trials had revealed the need for stimuli with strong plosive onsets to facilitate precise measurement on the computer screen. The monosyllabic stimulus was *dog*. Two stimuli from other studies were used, the dual-syllabic *cat-nose* (from Gathercole & Adams, 1993) and the multisyllabic *buttercup* (from Canning & Rose, 1974).

4.1.3 Proposed Battery of Tests

Tests had been constructed to assess conceptual language, phonological awareness, alphabet knowledge and articulation rate. However, where possible, tests with recognised standardisation data or those assumed to have some validity in the field of research (Gathercole & Baddeley, 1990a) were chosen. These tests were used to assess hearing, preliminary reading, verbal ability and phonological memory.

Hearing test

The Hearing Test Cards (RNID, Reed & Iliffe, 1987) were used to identify any child who suffered a significant hearing loss. The test was administered according to the instructions in the Handbook. Two children were withdrawn from the study at this point.

Reading test

Each child was given the Single Word Reading Test of the British Abilities Scale (Elliott et al., 1983). Testing is normally discontinued when the child fails to read ten successive words, however, for this study which demanded that all the children were at a preliterate stage, a child was removed from the sample if he or she was able to read one word. Six children were able to read and therefore replaced for the study by six non-readers.

Test of verbal ability

The Long Form of the British Picture Vocabulary Scale (Dunn & Dunn, 1982) was included. This test has been shown to correlate ($r = 0.8$) with the Stanford-Binet intelligence measure (Terman & Merrill, 1973) and is therefore thought to approximate to IQ. In this test the child was asked to choose, from a selection of four, the one picture which corresponded to the stimulus word spoken by the test administrator.

Tests of phonological memory

Two tests of phonological memory were included in the battery.

Digit Span

For the first phonological memory measure, Subtest A of the British Ability Scales (Elliott et al., 1983) was used. In this test, blocks of random digits were read aloud and the child was required to repeat the digits immediately in sequential order to *Mr Buttercup.* Each block contained five items, starting with a two-digit span block and increasing in length by one digit for each subsequent block. The test procedure for Subtest A detailed in the Instruction Manual was followed and testing was discontinued when the child made five errors in one block. This test was scored as recommended in the Instruction Manual (Elliott et al., 1983) by awarding one point for each correct serial item.

Nonword repetition

The second measure of phonological memory was the Children's Test of Nonword Repetition (Gathercole et al., 1994b). This test consisted of 40 nonwords, ten each of two, three, four, and five syllable length. Some evidence from previous studies suggested that young children responded more favourably to 'live' presentation of the stimulus words rather than to a pre-recorded audio tape presentation (Adams, in personal conversation, 24.01.95). In this study, the stimulus words were therefore spoken in the same sequence by the experimenter. The child was asked to repeat each word individually to *Mr Buttercup*. Each item was scored as correct or incorrect at the time of administration.

4.1.4 The Sample

From an original sample of 32 children, 30 children (17 boys and 13 girls) took part in the pilot study. The mean age of the group was 4 years 6 months (SD = 4.13 months; range = 3 years 10 months to 4 years 11 months).

The children were attending a total of five playgroups or nurseries in two neighbouring counties in South West England. The five centres were all in urban settings and served catchment areas with mixed owner-occupier and council-owned housing. Three of the nurseries were managed and funded by the Local Education Authorities, one playgroup was privately owned but attached to a Local Authority school and the remaining playgroup was part-funded by and attached to a local Anglican church.

4.1.5 Tests and Procedures

For the pilot study, all tests were carried out in the child's own nursery or playgroup. Each child was tested individually in three sessions spread over a three week period in the term prior to school entry. All tests and subtests were presented in a fixed order. However, the number of tests administered in a given session varied marginally depending on the attention span of the individual child.

The battery of tests was administered following the procedures described earlier in this chapter.

4.2 Results

Most studies of phonological awareness and phonological memory have employed parametric tests for analysis of the data (for example, Bryant & Bradley, 1985; Gathercole et al., 1991). Parametric analysis demands that the data should be of interval or ratio level, be derived from normal (or near normal) distributions and have homogeneity of variance (Coolican, 1992).

The data in this study did not, however, fully meet the criteria for parametric analysis. Although the majority of variables in the study were measured on a ratio scale, some indicated large standard deviations and skewed distributions. For this reason, where appropriate, the data were also subjected to descriptive and non-parametric techniques. Where data was on an interval scale but the distribution was skewed, measures of central tendency, for example the median score and the range of the scores, were considered to be more informative.

Phonological awareness, phonological memory and general verbal ability

The median scores and mean performance of the children on the tests of phonological awareness, phonological memory and general verbal ability are shown in Table 7.

Table 7 Performance on the pilot tests of phonological awareness, phonological memory and general verbal ability (means and standard deviations)

Test	Score
Phonological Awareness	
(raw scores, maximum in parentheses where relevant)	
Alliteration (10)	4.06 (2.63)
Rhyme detection (10)	6.43 (2.80)
Rhyme production (10)	5.26 (4.33)
Phonological Memory	
Span	11.33 (3.26)
Nonword repetition (40)	18.36 (6.40)
General verbal ability	
BPVS	37.03 (11.47)

Phonological awareness

Although the words chosen for the phonological awareness tasks were age-appropriate (Walley & Metsala, 1992) and the pictures had been trialled earlier with a group of 20 children, some children in this pilot study sample had difficulty in naming the items and had therefore been unable to complete the tasks unaided.

Phonological memory

The age-equivalent of the score for the digit span test according to the Handbook was 4 years 3 months to 4 years 5 months. The mean score for the nonword repetition test was in line with the normative scores given for children from 4.00 years to 4 years 11 months (Gathercole et al., 1994).

Verbal ability

The mean score on this test gave an age-equivalent score of 4 years 6 months and a quotient of 98. The sample was therefore considered to be representative of the population of children of this age.

Alphabetic knowledge

It had been predicted that scores on the tests of alphabet knowledge would be low in this sample of pre-schoolers. As anticipated, the distribution of scores was skewed and measures of central tendency were therefore calculated. Table 8 shows the mean and median scores for performance on the four tests of alphabetic knowledge.

Table 8 Mean and median scores on the pilot tests of alphabetic knowledge (with standard deviations and range)

Test	Mean		Median	
Letter name knowledge				
Aural presentation	3.26	(5.06)	1.0	(0-20)
Visual presentation	2.73	(4.52)	1.0	(0-22)
Letter sound knowledge				
Aural presentation	2.53	(4.79)	1.0	(0-20)
Visual presentation	1.46	(3.72)	0	(0-20)

At this pre-school stage of testing, knowledge of letter names was found to be better than knowledge of letter sounds. For both measures, letter names and letter sounds, scores in the aural presentation mode were higher than scores in the visual presentation mode.

Reliability

The first aim of the pilot study was to assess the reliability of the constructed tests. Based on the findings from her own study, Yopp (1988) declared reliability to be 'an important consideration in test selection for both classroom and research use.' (p. 172). A co-efficient of .85 is recommended before tests can be reliably used to make decisions about individuals (Hills, 1981). The reliability of each test was assessed first using a measure of internal consistency, Cronbach's alpha (Cronbach, 1951). To confirm the optimum number of items for each task, the Spearman-Brown correction formula was applied (Youngman & Eggleston, 1982) while item analysis (Skurnik & Nuttall, 1987) was used to determine the facility and discriminatory rating of each item.

Phonological awareness

The reliability of each phonological awareness test was assessed using Cronbach's alpha and then adjusted where appropriate using the Spearman-Brown formula. For example, the original alliteration task included ten items which gave a reliability co-efficient of .72 (Cronbach's alpha). Following application of the Spearman-Brown formula, two items were removed (*fork, wheelbarrow, worm, witch* and *kite, teapot, kettle, key*), leaving eight items which increased reliability to .86 (Cronbach's alpha). Table 9 shows reliability coefficients before and after correction for each test. The final lists of stimulus words are shown at Appendix D.

Table 9 Pre- and post-correction (Spearman-Brown)) reliability scores for pilot study tests of phonological awareness (with number of items)

	Cronbach's alpha	
	pre correction	post correction
Allit	.72 (10)	.86 (8)
RhyD	.79 (10)	.87 (8)
RhyP	.96 (10)	.96 (10)*

*No adjustment to item length was made for this test

Validity

Phonological awareness

The second aim of the pilot study was to assess whether the tests adequately measured the children's abilities. Table 10 shows the correlation coefficients between the raw scores for the phonological awareness measures. Significant associations between variables which purport to assess the same underlying construct have previously been taken as evidence that these correlated measures provide a 'high degree of stability' in measuring the same construct (Gathercole, Adams & Hitch, 1994, p. 203).

Table 10 Correlations between pilot study measures of phonological awareness

	Allit	RhyD	RhyP
Allit	-	-	-
RhyD	.38*	-	-
RhyP	.42 *	.79***	-

* p < .05; ** p < .01; ***p <.001.

The correlations between the coefficients in Table 10 demonstrate the content validity of the phonological awareness tests; all appeared to test the same underlying ability. Face validity of the tests was confirmed by ten primary school teachers who were not participating in the study. The ten teachers assessed the tasks to be appropriate measures of the construct phonological awareness.

Alphabet knowledge

Table 11 shows the correlation coefficients between the raw scores for the measures of alphabetic knowledge.

Table 11 Correlations between pilot study measures of alphabetic knowledge

	Letter			
	names		sounds	
	aural	visual	aural	visual
LN (a)	-	-	-	-
LN (v)	.90**	-	-	-
LS (a)	.60**	.46**	-	-
LS (v)	.32*	.30*	.79**	-

* p < .05; ** p < .01; ***p<.001

Correlational data has been used previously as evidence of concurrent validity (for example, Stuart & Coltheart, 1988). From the significant inter-correlations shown in the table, these four tests were considered to be valid measures of alphabetic knowledge.

Item Difficulty

The third aim of the pilot study was to assess the appropriateness of the tests for use with very young children.

Phonological awareness

Item analysis (Skurnik & Newell, 1987) was used to identify the facility order for presentation of items in the main study. Details of the analyses are shown at Appendix E.

Alphabet knowledge

Item analysis (Skurnick & Newell, 1987) of the four alphabet tests indicated that letter sounds and letter names were learned in different orders. Two separate lists were therefore constructed for the main study. These orders of presentation are shown at Appendix F.

Phonological memory

Item difficulty was assessed and considered appropriate by the standardisation details for each of these tests.

Speech rate

It has been suggested that the same stimuli may be used for tests of speech rate and phonological memory (Hulme et al., 1984). Two words in the nonword repetition task, *diller* and *pennel,* were successfully repeated by all children. These would be included in the main study together with two two-digit stimuli from the digit span task. The phonetic suitability of the digits for the computerised measurement procedure was trialled with ten children who were not participants in either the pilot or main studies. The final list of speech rate stimuli is shown at Appendix G.

4.3 Discussion

The pilot study assessed the validity, reliability and suitability of a number of tests which could examine the relationship between phonological awareness and phonological memory in young children. Adjustments to the task battery were made based on the results of statistical analysis. Methodological issues were also considered.

Timing and mode of presentation arose as two major issues from the pilot study. The battery was reordered to place the digit span task near the beginning of the second session because of its comparative brevity. The verbal ability task (Dunn & Dunn, 1982) was the longest test to administer and was moved to the end of the first session. For the alphabetic knowledge tasks, visual presentation would precede aural presentation to eliminate possible training effects. The duration of these tasks would be lessened by creating two books, each displaying the full 26 letters of the alphabet. The five letters grouped on each page would be chosen to ensure the most familiar letters, identified by the item facility analysis (Skurnik & Newell, 1987) were distributed evenly throughout the books.

The questionnaires which focused on the instruction of alphabetic knowledge were adapted so that the pre-school staff and reception class teachers would be asked to rank by importance the five pre-reading skills given. The reception class teachers would also be asked to rank by frequency the four methods of reading instruction and to identify which of three literacy support techniques they employed.

Assessment from the workbook of general language ability suggested conceptual understanding of 'two things which are the same' to be more reliable in very young children than understanding of 'the one which is the odd-man-out'. The workbook would not be used in the main study, but the terminology in the phonological awareness tasks would be adjusted to match the children's linguistic development. The phonological awareness picture stimuli would also be presented in book format as shown at Appendix H.

The pilot study assessed the tasks for the first stage of testing. However, in order to investigate the contribution of phonological awareness and phonological memory to subsequent literacy, three other tests were added to the battery for use at the final stage of testing. These were the Primary Reading Test (France, 1981) together with the nonword reading and the nonword spelling test devised by Huxford (1993). A general intelligence measure was also added at the final stage to ensure the sample was representative of the five year old population (BAS, Elliott, 1994). The final battery of tests and assessment points are shown in Table 12.

Table 12 Final battery of tests and assessment points

Tests	Stage 1	Stage 2	Stage 3
General ability			
Alphabetic knowledge	•	•	•
Alphabetic writing	•		
BAS ability			•
Hearing	•		
Verbal ability (BPVS)	•		
Phonological awareness			
Alliteration	•	•	•
Rhyme detection	•	•	•
Rhyme production	•	•	•
Phonological memory			
Articulation rate	•		•
Digit span	•	•	•
Nonword repetition	•	•	•
Literacy			
BAS reading	•	•	•
France reading			•
Nonword reading			•
Nonword spelling			•

CHAPTER 5

THE RELATIONSHIP BETWEEN PHONOLOGICAL AWARENESS AND PHONOLOGICAL MEMORY AT THE PRELITERATE STAGE

Introduction and Outline of Chapter

A longitudinal study had been designed to evaluate the relationship between two phonological processing skills, phonological awareness and phonological memory, in a group of preliterate children as they moved through the early stages of literacy acquisition. Results reported here from the first stage of testing, when all the children were assessed to be at a 'pre-reading' stage of development, suggest that individual ability to produce and detect rhymes may be heavily dependent on phonological memory skills. However, sensitivity to the first sound in a word, that is sensitivity at the phonemic level, appears to reflect a separate phonological processing skill which is uninfluenced by phonological memory. This chapter reports the data and discusses the findings under the following headings:

- methodology of the longitudinal study
- results
- discussion
- summary

5.1 Methodology of the longitudinal study

From the literature reviewed earlier (Chapter 1 and Chapter 2), it would seem that research into the development of reading has been as diverse in methodology as it has been extensive in quantity. The viability of a number of research designs was considered at the planning stage of the current study (Chapter 3). Each design was considered in terms of its suitability to meet the proposed research aims together with its perceived advantages and disadvantages in terms of its practical application and collection of appropriate data.

5.1.1 Aims

There is some evidence of a strong and consistent association between reading development in the early school years and two phonological processing abilities, phonological awareness and phonological memory. Despite this, it would seem that developmental psychologists have tended to focus on the role of phonological awareness in the reading process while cognitive psychologists have tended to centre their interest on phonological memory and a range of more general linguistic skills including reading.

From the studies reviewed earlier in Chapter 1, it seems that in spite of the general acceptance of an association between reading and phonological awareness, there is still no consensus as to whether phonological awareness is a precursor to or consequence of learning to read. One explanation for the discrepant results between studies is that phonological awareness is not an homogenous skill, but may reflect a range of skills which are differentially associated with early reading (Bryant et al., 1990; Yopp, 1988). Furthermore, Bowey and Patel (1988) have suggested that the association between awareness of rhyme and reading performance may simply be determined by general language ability.

Several investigations into the verbal span deficits of poor readers have similarly reported a specific association between phonological memory and reading acquisition (for example, Ellis & Large, 1988; Mann & Libermann, 1984; Shankweiler et al., 1979;). However, this evidence has typically come from cross-sectional studies which cannot rule out the alternative causal hypothesis, that phonological memory may be enhanced by learning to read

From a detailed search of the literature, it would appear that to date no study has employed a longitudinal model to monitor the developmental relationship between these two phonological processing skills and reading. A three-stage longitudinal study was therefore designed to trace the development of phonological awareness and phonological memory in a group of preliterate children as they entered school and began to read.

The aim at the preliminary stage of the study was to investigate the relationship between phonological awareness, phonological memory and general verbal ability before the children learned to read.

5.1.2 <u>The Sample</u>

A total of 80 children (37 boys and 43 girls) made up the cohort throughout the 18 month duration of the study. For the longitudinal study, assessments were taken at three points: the first was during the final term of nursery education, the second after six months in school, and the third at the end of the first year of formal schooling.

At the start of the study the children were attending a total of eight playgroups or nurseries in two neighbouring counties in South West England. Four of the nurseries were managed and funded by the Local Education Authorities, one playgroup was privately owned but attached to a Local Authority school, one nursery was owned by a large child-care organisation, one nursery was privately owned and the remaining nursery was attached to a large independent school. The mean age of the group at this time was 4 years 7 months (SD = 1.22 months; range - 4 years 6 months to 4 years 10 months).

At the second stage of testing the children had transferred into 23 primary schools and one independent pre-preparatory school. The mean age of the group at this time was 5 years 2 months (SD = 1.22 months; range - 5 years 1 month to 5 years 5 months).

At the final stage of testing the children had moved into 26 primary schools and one independent pre-preparatory school. The mean age of the group at this time was 5 years 8 months (SD = 1.22 months; range - 5 years 7 months to 5 years 11 months).

5.1.3 Tests and Procedures

For the initial battery of tests, each child was tested individually in three 30 minute sessions over a two week period. Testing took place in a quiet room in the child's own nursery or playgroup.

At the first stage, a preliminary reading test (the single word Reading Test of the British Abilities Scale, Elliott et al., 1983) was given to ensure all the children were at a preliterate stage. Any child able to read a single word was excluded. No children were able to read. Each child was given the RNID Hearing Test (Reed & Iliffe, 1987) and children with any hearing impairment were withdrawn from the study. No child was found to have a significant hearing impairment.

Phonological processing ability was assessed using the same tasks throughout the study. Phonological awareness was assessed by three tasks, alliteration, rhyme detection and rhyme production. The procedure for these tests has been described earlier (see Chapter 4). Phonological memory was assessed by two tasks also described earlier, the nonword repetition task (Gathercole et al., 1994) and the digit span subtest of the British Abilities Scale (Elliott et al., 1983). The Long Form of the British Picture Vocabulary Test (Dunn & Dunn, 1982) was also given at the first stage of testing.

There were four tasks which assessed the children's knowledge of the alphabet. The materials and procedure for these have been previously described (Chapter 4). An assessment of the children's ability to write in an alphabetic script was also made using the Write-Name task described in the previous chapter.

At the first stage of testing, measures were also taken of the children's speech rate following the procedure adopted in the pilot study and described previously.

5.2 Results

This section presents the data which address the first research question.

5.2.1 What is the relationship between phonological awareness, phonological memory and general verbal ability in preliterate children?

The mean performance of the children on the tests of phonological processing and general verbal ability is shown in Table 13. Stuart and Coltheart (1988) corrected scores on their rhyme detection and alliteration tasks, arguing that choosing the odd man out from three gives a 33% chance of being right by chance (Stuart, personal communication, 1996). If scores are adjusted to account for chance, to be fair all scores should be adjusted. Such *adjustment for chance scoring would seem feasible* for the child who scores, say, 2 points or less in an 8-trial task. However, it would seem difficult to justify deducting 33% to account for chance from the child who scored at ceiling (8 points). According to the 'chance' reasoning, 2.67 (rounded to 3) of his/her successes could be attributed to chance and therefore this child's adjusted score would be 5 points. It would seem unreasonable to suggest that a child who is able to score maximum points was successful for any other reason than that he/she had a full grasp of the concept being assessed. Raw scores are therefore given in Table 13.

Table 13 Performance on tests of phonological awareness, phonological memory and general verbal ability at Stage 1 (means and standard deviations)

Test	Score
Phonological Awareness	
(raw scores, maximum in parentheses)	
Alliteration (8)	3.60 (2.04)
Rhyme detection (8)	4.79 (2.23)
Rhyme production (10)	4.43 (4.43)
Phonological Memory	
Span	11.0 (2.74)
Nonword repetition (40)	21.5 (4.96)
General verbal ability	
BPVS	40.24* (10.95)

* Age equivalent 4 years 6 months; quotient 101.

Table 13 shows a mean score for general verbal ability of 40.24 (SD = 10.95) and the sample was therefore considered to be representative of the population of children of this age. The underlying distribution of scores on the rhyme production task was found to be bimodal and was, therefore, entered as a dichotomous variable. The statistical significance of subsequent coefficients, as shown in Table 14, was obtained using point-biserial tables.

Correlational Analysis

Table 14 shows the correlation coefficients between the raw scores for the principal phonological processing and the general verbal ability measures at Stage 1.

Table 14 Correlations between Stage 1 measures of phonological awareness, phonological memory and general verbal ability

	Allit	RhyD	RhyP	Repet	Span
Allit	-	-	-	-	-
RhyD	.35**	-	-	-	-
RhyP	.20	.54***	-	-	-
Repet.	.19	.37***	.46***	-	-
Span	.21	.41***	.55***	.53***	-
BPVS	.21	.31**	.26*	.44***	.36**

* p < .05; ** p < .01; ***p < .001.

Correlations between tests of phonological awareness

At the first stage of testing, rhyme detection and rhyme production were significantly associated ($r = .54$, $p < .001$). Although alliteration was significantly associated with rhyme detection ($r = .35$, $p < .01$) no significant association was found with rhyme production.

Correlations between tests of phonological memory

A significant association was found between the two measures of phonological memory, nonword repetition and digit span ($r = .53$, $p < .001$).

Correlations between tests of phonological awareness and phonological memory

Rhyme detection was significantly associated with span ($r = .41$, $p < .001$) and nonword repetition ($r = .37$, $p < .001$). Rhyme production was significantly associated with both measures: span ($r = .55$, $p < .001$) and nonword repetition ($r = .46$, $p < .001$). No significant association was found between alliteration and either measure of phonological memory.

Correlations between general verbal ability and tests of phonological awareness and phonological memory

In terms of the relationship between general verbal ability and measures of phonological awareness, a significant association was found with rhyme detection ($r = .31$, $p < .01$) and rhyme production ($r = .26$, $p < .05$). Similarly, a significant association was found between general verbal ability and the two measures of phonological memory, span ($r = .36$, $p < .001$) and nonword repetition ($r = .44$, $p < .001$). However, there appeared to be no significant relationship between general verbal ability and alliteration.

The significant correlations between variables could result from shared underlying factors; a factor analysis was therefore used to investigate this.

Factor Analyses

Factor analysis is a statistical procedure which is commonly used to identify underlying patterns of relationship between variables (Nie, Hull, Jenkins, Steinbrenner & Bent, 1975). It was used at this stage in the study to examine more specifically the underlying patterns of association between phonological awareness and phonological memory.

Phonological awareness, phonological memory and general verbal ability

There are several forms of factor analysis. A principal components analysis was carried out on the correlation matrix for the phonological awareness, phonological memory and verbal ability variables. In a principal components analysis, there are initially as many factors as variables but the first factor represents the cluster of variables which account for most of the variance in the data. Doise, Clemence and Lorenzi-Cioldi (1993) recommend the selection only of factors which account for more of the variance in the data than can be explained by a single variable (that is where the eigenvalue is > 1). It has been suggested, however, this 'default criterion' should be reconsidered in the case of a factor which fails to meet the criterion yet makes a further significant contribution to variance (Tucker, Koopman & Linn, 1969).

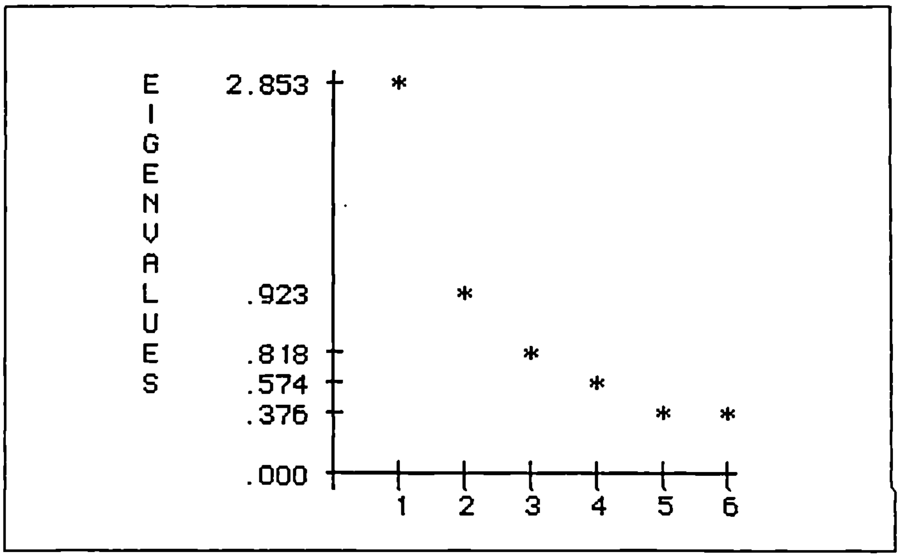
The original factor matrix was subjected to orthogonal rotation to minimise the number of variables which had high loadings on each factor. Table 15 displays the loadings of the phonological processing tasks and general verbal ability after rotation.

Table 15 Factors, communality, eigenvalues and contribution to variance (%) from principal components analysis of measures of phonological awareness, phonological memory and general verbal ability at Stage 1

Factor	Communality	Eigenvalue	Variance (%)	Cumulative variance (%)
1	.91	2.85	47.5	47.5
2	.85	0.92	15.4	62.9
3	.68	0.82	13.6	76.6
4	.68	0.58	9.6	86.1
5	.79	0.46	7.6	93.7
6	.66	0.37	6.3	100.0

As Table 15 demonstrates, only one factor met the recommended eigenvalue criterion (>1). However, second and third factors which had eigenvalues below the recommended default value also accounted for further significant portions of the total variance. An interim scree test (Cattell, 1966) was carried out on this data. Scree is a geological term which describes the debris found on lower rocky mountain slopes; scree plots are statistical tests which show a distinct break between the steep slope of the large factors and the gradual trailing off of the other factors. The scree plot is shown in Fig. 7.

Fig. 7 Plot of eigenvalues and factors from scree test (Cattell, 1966) for measures of phonological awareness, phonological memory and general verbal ability at Stage 1



A three-factor model, where these factors accounted for a total 76.6% of variance, was therefore adopted. Table 16 shows the factor loadings for the general verbal ability and phonological processing variables.

Table 16 Stage 1 factor loadings of phonological awareness, *phonological memory and general verbal ability* (orthogonal Varimax solutions from factor analysis are shown)

Variable	Factor 1	Factor 2	Factor 3
Allit	.11	.12	**.94**
BPVS	.08	**.90**	.18
RhyD	**.60**	.09	**.64**
RhyP	**.88**	.10	.08
Repet.	**.52**	**.64**	-.01
Span	**.71**	**.41**	.01

Note. Numbers in bold are significant at the 1 per cent level (Burt-Banks formula, 1947).

The criteria for selection of factors has been described in a previous chapter (Chapter 3). Walsh (1990) suggests the recommendation that each factor should have a minimum of three variables for 'meaningful interpretation' (p. 335), may be modified where the data set consists of eight variables or less. The three factors indicated by the scree test were therefore retained in this analysis. As Table 16 shows, the four measures of phonological processing, rhyme detection, rhyme production, digit span and nonword repetition loaded significantly on the first factor. Both phonological memory measures (nonword repetition and digit span) loaded highly on Factor 2 with general verbal ability while rhyme detection loaded moderately on Factor 3 with alliteration. This pattern of associations suggests there may be a common component underpinning the phonological memory and rhyme awareness measures. General verbal ability appeared to be uniquely associated with the two phonological memory measures. The clear distinction between alliteration and the two measures of rhyme, rhyme detection and rhyme production, would seem to suggest that separate skills may underlie the construct commonly labelled 'phonological awareness'.

In order to investigate this apparent dissociation between alliteration and rhyme awareness measures further, a second factor analysis was computed for the three measures used in this study to assess phonological awareness. The factor matrix was again subjected to orthogonal rotation. Table 17 displays the eigenvalues and contribution of the phonological awareness tasks and general verbal ability after rotation.

Table 17 Factors, communality, eigenvalues and contribution to variance (%) from principal components analysis of measures of phonological awareness and general verbal ability at Stage 1

Factor	Communality	Eigenvalue	Variance (%)	Cumulative variance (%)
1	.89	1.96	49.1	49.1
2	.37	.82	20.5	69.6
3	.72	.79	19.7	89.3
4	.80	.43	10.7	100.0

As Table 17 shows, only the first factor exceeded the eigenvalue >1 criterion. However, as a second factor (eigenvalue .82) accounted for a further significant portion of the variance (20.5%), a Cattell's (1966) scree test was again applied to data. As before, the scree test suggested that a three factor model may be appropriate. The result of the scree test is shown at Appendix J together with the factor loadings for each variable. However, in this three factor model, two variables loaded on the first factor, but only one variable was found to load on each of the other two factors. The three factor model was therefore considered to be unsuitable and a two factor model was adopted. Table 18 shows the factor loadings for the phonological awareness and general verbal ability measures.

Table 18 Stage 1 factor loadings of phonological awareness measures (orthogonal Varimax solutions from factor analysis are shown)

Variable	Factor 1	Factor 2
Allit	.09	**.94**
BPVS	**.44**	**.42**
RhyD	**.79**	**.31**
RhyP	**.89**	.01

Note. Numbers in bold are significant at the 1 per cent level (Burt-Banks formula, 1947).

From the results of this factor analysis, the two rhyme measures were found to load significantly on the first factor with general verbal ability. Alliteration, however, loaded significantly on a separate second factor but was also shown to be associated with the general verbal ability and rhyme detection measures. The pattern of association here would seem to confirm the findings of the previous factor analysis (Table 16) that phonological awareness may not be an homogenous skill.

The results of the first factor analysis (Table 16) suggest a commonality, reflected by the Factor 1 loadings, between phonological memory and the two measures of phonological awareness, rhyme detection and rhyme production. The memory load of phonological awareness tasks has been previously questioned (Wagner & Torgesen, 1987). In order to identify the phonological memory requirements of the two rhyme tasks, rhyme detection and rhyme production, prior to the statistical analysis, two task analyses were carried out. The results of the task analysis for each measure are shown at Appendix K and Appendix L. A summary of the task analyses is shown in Table 19.

Table 19 Task analysis of Stage 1 measures of rhyme detection and rhyme production to show cognitive processes

Cognitive process	Rhyme detection	Rhyme production
see stimulus picture(s)	•	•
hear stimulus word(s)	•	•
encode visual to phonological representation ‡	•*	•*
articulate/repeat stimulus item	•	
hold stimulus items(s) in memory ‡	•	•
isolate particular sound (rime) ‡	•	•
compare rimes ‡	•	
delete initial phoneme ‡		•
substitute initial phoneme ‡		•
reblend onset-rime ‡		•
verify from lexicon		•*
make judgement	•	•
articulate response ‡	•*	•

* optional procedure may not be used by all children
‡ demands generation of phonological representation or rehearsal

The task analysis seemed to confirm the considerable influence of phonological memory in tasks which aim to assess rhyme awareness. Although Wagner and Torgesen (1987) claim that rhyming tasks which purport to assess phonological awareness are more measures of phonological memory than phonological awareness, these authors also argue that to date this has not been statistically assessed. To investigate further the contribution of phonological memory to tasks of rhyme awareness two regression analyses were carried out.

Regression Analyses

The criteria for and advantages of regression techniques in psychological research have been discussed previously (Chapter 3). Regression analyses have been used frequently in developmental studies of reading to determine the variance shared between reading and a range of phonological processing tasks (for example, Bryant et al., 1990). Stepwise regression analyses, where independent variables are selected from a hierarchy based on the highest partial correlations, were used in this instance (Norusis, 1988).

The results of the first analysis which assessed the contribution of phonological memory to variance in the rhyme detection task are shown in Table 20.

Table 20 Multiple (stepwise) regression of Stage 1 phonological memory measures (digit span and nonword repetition) on rhyme detection

Outcome Measure: **rhyme detection (Stage 1)**							
Dependent Variable	b	s.e.	B	*t*	sig	R^2	R^2 change
Span	.33	.08	.41	3.96	.00	.17	.17
Repet					ns		
(Constant)	1.12	.95		1.18	.24		

Adjusted R squared = .16, F = 15.7, p = .000, N = 80

The results from this analysis confirmed that one measure of phonological memory, digit span, accounted for a significant 17% of variance in performance on the rhyme detection task. The second analysis assessed the contribution made by phonological memory to performance on the rhyme production task. The results are shown in Table 21.

Table 21 Multiple (stepwise) regression of Stage 1 phonological memory measures (digit span and nonword repetition) on rhyme production

Outcome Measure: **rhyme production (Stage 1)**							
Dependent Variable	b	s.e.	B	*t*	sig	R^2	R^2 change
Span	.70	.17	.43	3.96	.00	.30	.30
Repet	.20	.10	.23	2.10	.04	.34	.04
(Constant)	-7.64	2.00		-3.82	.00		

Adjusted R squared = .33, F = 20.13, p = .000, N = 80

The results from the second analysis suggest that, in total, phonological memory accounted for 34% of the variance in scores for the rhyme production task. These analyses confirm the significant influence of phonological memory in tasks which purport to assess phonological awareness.

5.3 Discussion

The first stage of this study was designed to assess the relationship between phonological awareness and phonological memory, and the association between these two phonological processing skills and general verbal ability in preliterate children. The results presented here showed that at a preliterate stage, general verbal ability, the three measures of phonological awareness and the two measures of phonological memory could be accounted for by three factors.

Results from the factor analyses revealed that two of the measures of phonological awareness, rhyme detection and rhyme production, loaded on one factor along with the two phonological memory measures (nonword repetition and digit span). The results of the multiple regression analyses confirmed the significant contribution of phonological memory to the two rhyming tasks. It may therefore be the case that Factor 1 reflects underlying phonological memory skill.

If, as has been previously assumed (Gathercole et al., 1991), the common component underlying these Factor 1 measures were to be a general phonological processing ability, it could be reasonably expected that general verbal ability would load similarly on this factor. This was not the case. Moreover, general verbal ability loaded highly on the second factor along with the measures of phonological memory. Comparable associations between the nonword repetition measure of phonological memory and general verbal ability have been cited in other studies (for example, Gathercole et al., 1991). This association between phonological memory and general verbal ability has led to previous claims that short-term phonological memory function influences vocabulary development (Gathercole & Baddeley, 1989; Gathercole et al., 1991). However, from the data reported here, an alternative explanation could be that performance on nonword repetition tasks may be enhanced by general verbal ability. It would seem plausible that the child who already has the real words *actually* or *tallest* stored in a long term lexicon, may be able to respond more readily to nonword stimuli such as *confrantually* or *tafflest*. A comparable association between lexical knowledge and phonological memory performance has been noted previously (Hulme et al., 1991). In the present study, two nonwords, *diller* and *pennel* were correctly repeated from the first assessment point by a majority of children. It would seem likely that phonologically similar words such as *pillow* (pronounced *piller* in the local dialect) and *kennel* would be in the spoken vocabulary of most children of this age: these real words may have considerably influenced performance on the nonword task. Similarly, children's previous experience in rote counting a sequence of numbers has been found to influence their performance on a digit span task (Gathercole & Adams, 1994). Thus, from the results shown in Table 16, it could be argued that previous language experience may underpin the Factor 2 variables. Factor 2 may therefore be interpreted as reflecting a general underlying verbal ability.

The literature search reported in Chapter 1 revealed a number of claims that alliteration and rhyme awareness may reflect separate underlying skills unrelated to general verbal ability (for example, Goswami & Bryant, 1990; Yopp, 1988). The significant loading of the rhyme production measure on the phonological memory factor may suggest the score for rhyme production in this study should not be interpreted as a measure of phonological awareness but rather as a measure of phonological memory. Alliteration tasks have been included in a number of test batteries to assess phonological awareness at the single-sound or phonemic level (for example, Muter, 1994; Stuart & Coltheart, 1988). As anticipated from the floor effects observed in these earlier studies (Muter, 1994; Stuart & Coltheart, 1988), performance on the alliteration task in this study at the first stage of testing before the children could read, was low. This would seem to offer direct support to the studies discussed earlier (see Chapter 1) which suggest that awareness of phonemes is not present at the age of four years. However, as all the children in the study were unable to read, these findings cannot uphold the claim that phonemic awareness is acquired as a result of learning to read (for example Morais et al., 1987). The dissociation between alliteration and rhyme production in Table 17 and Table 18 does however concur with the proposal that phonological awareness may not be an homogenous skill (Bryant et al., 1990). It could be suggested from the results that Factor 3 may reflect underlying phonological awareness.

Performance on the rhyme detection task has been consistently reported as predictive of later reading achievement (for example, Bradley & Bryant, 1983; Bryant et al., 1990). The moderate loading of rhyme detection on Factor 1 (here labelled phonological memory)and also on Factor 3 (here labelled phonological awareness) could suggest that the rhyme detection task may simultaneously measure phonological memory and, possibly, phonological awareness. Positive correlations and factor loadings between this measure of phonological awareness and phonological memory have been previously noted in children during the early years of schooling (Gathercole et al., 1991). Similarly, the association found here between rhyme detection and alliteration in young children has been demonstrated in an earlier study (Bryant et al., 1990). If the variables loaded on Factor 3 are taken to reflect phonological awareness at the single sound or phoneme level, the association between alliteration and rhyme detection is puzzling. However, Treiman (1991) has argued that,

> ... because some tasks that purport to measure phonemic awareness test only single-consonants (i.e., one-phoneme onsets) and single final vowels (i.e., one phoneme-rimes), the tasks may actually measure awareness of onsets and rimes, not awareness of the phonemes that make up onsets and rimes.
> (p. 164)

As all the words used for the alliteration and rhyme detection tasks in this study were regular CVC (*consonant-vowel-*consonant) words, awareness at the onset-rime level may have been sufficient to guarantee success. If Factor 3 reflects phonological awareness at the intra-syllabic rather than the phonemic level, this may explain more satisfactorily why alliteration and rhyme detection were found to load on one factor. As both phonological awareness and phonological memory have been cited as 'predictors' of subsequent literacy success (Bradley & Bryant, 1983; Gathercole et al., 1991), this 'dual- factor' loading may account for the reported predictive efficiency of rhyme detection tasks.

Despite some confirmation of the findings of previous studies, the factor analysis in Table 18, adds no support to the claim that rhyme awareness and alliteration are unrelated to general verbal ability (Goswami & Bryant, 1990). An initial explanation of this might follow Bowey and Patel's (1988) line of reasoning that rhyme performance may be determined by general language ability.

However, from the results of the analysis in Table 16, some support for Goswami and Bryant's (1990) claim arises when the phonological memory measures are included in the analysis. Rhyme detection and rhyme production appear to share a common phonological processing factor with phonological memory which appears to be relatively uninfluenced by general verbal ability.

Awareness of rhyme at four years of age before a child learns to read is thought to offer a good measure of a child's ability to categorise words by sound (Bryant et al., 1990). However, in this study at the first stage of testing, a number of children who found the rhyme production task difficult were not able to complete the nursery rhyme used as a cue prior to the test. As no measure was taken of the children's knowledge of nursery rhymes, it could be argued that successful performance on this task may have reflected acquired learning, arguably facilitated by adequate phonological memory ability, rather than a genuine metalinguistic skill.

Summary

The chapter reported the data on the relationship between two phonological processing skills, phonological awareness and phonological memory, at a preliterate stage. The results presented here confirm that a significant relationship exists between phonological memory and two of the tasks used to assess phonological awareness, rhyme detection and rhyme production.

Previous explanations of this association have suggested that these two phonological skills, phonological awareness and phonological memory, reflect a unitary underlying processing component. Detailed analyses of the data, however, would seem to suggest that rather than reflecting a common processing component, tests of rhyme production and to a lesser extent, tests of rhyme detection, given at a preliterate stage, may measure phonological memory ability rather than phonological awareness. Alliteration in this study maybe said to reflect phonological awareness at the intra-syllabic level.

The next chapter reports and discusses the data at the end of the first year in school and investigates the influence of these preliterate phonological processing skills on subsequent reading and spelling ability.

6.1 Methodology of the Longitudinal Study

The advantages of the longitudinal approach to research in education has been discussed previously (Chapter 3). The results presented in this chapter are from the data collected 15 months after the first stage of testing. At this final stage of the study, the children were in the final three weeks of their first year in school.

6.1.1 Aims

Despite some claims that a significant relationship exists between reading and two phonological processing skills, phonological awareness and phonological memory (for example, Crain et al., 1990; Gathercole et al., 1991), most studies have neglected to assess the development of these skills over a period of time in the same group of children. As a result, little is known of the relative contribution of each of these skills to early literacy.

Evidence from one cross-sectional study of a sample of four and five year old beginning readers (Gathercole et al., 1991) suggested that, despite some evidence of a common underlying phonological processing component, phonological awareness and phonological memory also made distinct and separable contributions to reading development. In that study, whereas an association was found between reading and phonological awareness in both the four year old and the five year old group, a similar relationship between reading and phonological memory appeared only after the children had been in school for one year. These distinct associations with reading were taken as evidence that the two phonological processes reflect separate underlying cognitive skills. As most of the younger children were non-readers, these claims may need to be interpreted with some caution.

The disadvantage of the cross-sectional study design has been discussed in a previous chapter (see Chapter 3). The claim that phonological memory is closely associated with reading after one year in school (Gathercole et al., 1991) cannot determine whether proficient phonological memory abilities at a preliterate stage facilitate reading or whether, conversely, phonological memory is itself enhanced by learning to read. The first aim of this section of the longitudinal study was to address this by assessing the relative contributions of preliterate phonological awareness and phonological memory to the acquisition of literacy after one year in school. The second aim of this section was to determine whether phonological awareness and phonological memory reflect one unitary underlying skill.

6.1.2 The Sample

The sample suffered no attrition and the cohort remained the same throughout the study. The mean age of the group and locations at each stage of testing were outlined in the previous chapter.

6.1.3 Tests and Procedures

Phonological awareness and phonological memory

The same tests were used to assess phonological processing throughout the study; the materials and procedures have been described previously in Chapter 4.

Verbal ability

As previously reported (see Chapter 4), general verbal ability was assessed at Stage 1 by the Long Form of the British Picture Vocabulary Scale (Dunn & Dunn, 1982). At the final stage of testing, a 'g' enhanced Short Form of the British Ability Scale (Elliott, 1994) was used to confirm the sample was representative of the six year old population. In this context, 'g' is thought to represent 'the general ability of an individual to perform complex mental processing that involves conceptualisation and the transformation of information' (Elliott, 1990). Elliott (1994) claims that this 'g'-saturated measure' provides both a theoretically satisfactory and a usefully practical measure of ability even for children who are experiencing learning difficulties. The 'g' enhanced Short Form consisted of the Block Design, Word Definition, Matrices and Similarities subtests.

Reading and spelling

Reading ability was assessed at each stage by a standardised test of single word recognition (BAS, Elliott et al., 1983). As some children failed to achieve the base reading age score for this test, raw scores were used throughout the study. At the final stage of testing, after one year in school, two further reading measures were employed: the multiple-choice Primary reading test (France, 1981) and the nonword reading test (Huxford, 1993).

The Primary reading test (France, 1981) has been used as a reading measure in a number of previous studies (for example, Bryant et al., 1990; Gathercole et al., 1991). In this multiple-choice test, the child is asked to name a picture aloud and then to identify the corresponding word from a selection of four printed alongside the picture. The standardisation details for Level 1A of this test suggest it to be appropriate for assessing children with reading ages ranging from 6 years 4 months to 8 years 9 months. As for the singe word recognition test (Elliott et al., 1983), raw scores rather than reading ages were used in the analyses.

In order to yield more information about the strategies which young children employ in early reading development, a nonword reading test was added to the final battery. As discussed in Chapter 1, it has been suggested that success in nonword reading tests can only be achieved by applying a phonemic or full phonological recoding strategy (Ehri, 1992; Ehri & Wilce, 1987). The nonword reading test (Huxford, 1993) was used at the final stage of testing. For this task, the children were shown 16 coloured picture cards which depicted individual animals from outer space. On each card the nonword names were printed below in lower case letters and the child was asked to read the name of each animal. There were four practice items and twelve trials. One mark was awarded if the whole word was read correctly. The list of nonwords is included at Appendix M. Based on some recent evidence that phonemic spelling ability occurs before phonemic reading ability (Cataldo & Ellis, 1990; Huxford, 1993), a nonword spelling test was also added to the final assessment battery.

The nonword spelling test (Huxford, 1993) employed the same corpus of nonwords and set of picture cards as the nonword reading test (Huxford, 1993). In this task, the experimenter named the animal illustrated on each picture card and the child was asked to assist in preparing a party invitation by 'writing' the animal's nonword name using plastic magnetic letters. There were four practice items and twelve trials. One mark was awarded if the whole word was spelled correctly.

6.2 Results

This section presents the data for the two research questions addressed by this part of the study:

- What are the relative contributions of preliterate phonological awareness, phonological memory and general verbal ability to literacy after one year in school?
- Are phonological awareness and phonological memory separable or do they reflect one unitary underlying skill?

6.2.1 What are the relative contributions of preliterate phonological awareness, phonological memory and general verbal ability to literacy after one year in school?

Three tests of phonological awareness, two tests of phonological memory and a test of single word reading were given at each stage of testing. Two additional tests of reading and one test of spelling were given at the final stage of testing. A test of general verbal ability was also given at the first stage of testing and a test of general cognitive ability was given at the final stage of testing. Table 22 shows the mean performance of the children on each of these tests.

Table 22 Performance on tests of phonological awareness, phonological memory and general verbal ability at Stage 1; phonological awareness, phonological memory and reading at Stage 2 and reading, spelling and general cognitive ability at Stage 3 (means and standard deviations)

Test	Stage 1	Stage 2	Stage 3
Phonological Awareness (raw scores, maximum in parentheses)			
Allit (8)	3.60 (2.04)	5.58 (2.57)	6.55 (2.16)
RhymeD (8)	4.79 (2.23)	5.80 (2.14)	6.67 (1.97)
RhymeP (10)	4.43 (4.43)	7.05 (4.14)	7.75 (3.79)
Phonological Memory			
Span	11.0 (2.74)	12.95 (2.58)	13.80 (3.02)
Repet (40)	21.5 (4.96)	26.90 (4.51)	29.61 (4.25)
Reading and Spelling (number of words)			
BAS reading (30)	0	3.01 (6.55)	11.00(14.07)
France reading (16)	-		12.45 (3.56)
Nonword reading (12)	-		4.40 (4.65)
Nonword spelling (12)	-		6.41 (4.77)
Cognitive Ability			
BPVS	40.24(10.95)		
BAS Ability Scale 'g' enhanced			109.78(9.93)

*p<.05;** p < .01; ***p<.001

A Jonckheere trend test applied to the scores shown in Table 22 demonstrate a significant developmental progression in all measures of phonological processing and single word reading ($p < .01$). At Stage 1 of testing, the rhyme production and alliteration tasks were noted to be more difficult which concurs with the findings of other studies on the development of phonological awareness (for example, Adams, 1990; Muter, Snowling & Taylor, 1994). In line with previous studies of children of this age (for example, Muter et al., 1994; Huxford, 1993), scores on three measures of literacy, the single-word reading test (BAS; Elliott et al., 1983), the nonword reading test (Huxford, 1993) and the nonword spelling test (Huxford, 1993) showed a positive skew, consistent with floor effects at the final stage of testing.

Scores on the BAS Ability Scale were significantly correlated ($r = .41; p < .001$) with the earlier British Picture Vocabulary Scale measure and suggested the sample to be within the normal range cited in the standardisation report for the test (Elliott, 1994).

Correlational Analysis

Correlational analysis was used to examine the relationship between the children's phonological processing and general verbal ability at the pre-literate stage and literacy skill at the final stage of the study. In the analysis, raw scores were used for measures which were normally distributed. The measures with skewed distributions underwent logarithmic transformations appropriate to their size and direction of skew (Tabachnick & Fidell, 1989). The bi-modally distributed scores were entered as a dichotomous variable and the statistical significance of the co-efficients assessed using point-biserial tables. Table 23 shows the correlations between these measures.

Table 23 Correlations between phonological processing and general verbal ability at Stage 1 and reading and spelling scores at Stage 3

	Stage 3			
	Reading (BAS)	Reading (France)	Reading (Nonword)	Spelling (Nonword)
Stage 1				
Alliteration	.28*	.35**	.19	.25*
Rhyme detection	.34**	.42***	.40***	.42***
Rhyme production	.27*	.27*	.40***	.41***
Span	.17	.31**	.39***	.46***
Repetition	.26*	.32**	.33**	.46***
BPVS	.38**	.31**	.41***	.45***

* $p < .05$; ** $p < .01$; *** $p < .001$

Preliterate phonological awareness and literacy after one year in school

Table 23 shows that rhyme detection and rhyme production correlated significantly with all the final measures of reading and spelling. Alliteration was significantly associated with the single-word reading test (BAS; Elliott et al., 1983), ($r = .28, p < .05$), the multiple-choice reading test (France, 1981) ($r = .35, p < .01$) and the nonword spelling test (Huxford, 1993), ($r = .25, p < .05$).

Preliterate phonological memory and literacy after one year in school

Nonword repetition scores correlated significantly with all measures of literacy taken at the final stage. Digit span scores were significantly correlated with the multiple-choice reading test (France, 1981) ($r = .31$, $p < .01$), the nonword reading test (Huxford, 1993), ($r = .39$, $p < .001$) and the nonword spelling test (Huxford, 1993), ($r = .46$, $p < .001$).

Preliterate general verbal ability and literacy after one year in school

A significant association was found between verbal ability (BPVS; Dunn & Dunn, 1982) at Stage 1 and each of the later measures of reading and spelling.

In general, the pattern of correlations suggested a significant relationship between early phonological processing skill and subsequent literacy ability. Verbal ability was also found to be significantly associated with all measures of reading and spelling. Simple correlational analysis cannot, however, assess the relative contribution of either the separate phonological skill components or general verbal ability to reading and spelling.

Multiple regression procedures have been typically used in a large number of studies to examine, for example, the relationship between preliterate phonological awareness or phonological memory and subsequent reading performance (for example, Muter et al., 1994; McDougall et al., 1994). However, as the scores on the reading and spelling tests in this study were not normally distributed before the logarithmic transformation, multiple regression analyses could not be used on the raw scores.

Analyses of Variance

Analyses of variance have been used previously to investigate the association between phonological processing tasks and non-normally distributed reading scores (MacLean et al., 1987; Gathercole et al., 1991). This section summarises the results of a series of analyses using this procedure. An example of the individual analysis tables is shown at Appendix N. Prior to each analysis, the children were divided into two groups based on the median score for the reading or spelling measure to be entered as the factor in that analysis. The good readers were those who scored above the median on the measure and the poor readers were those who scored below the median.

In four separate analyses, the effect of each variable on reading or spelling level was assessed by entering the scores from the preliterate phonological processing tasks, alliteration, rhyme detection, rhyme production, nonword repetition and digit span, in separate analyses of covariance, controlling for general verbal ability as a covariate in each.

BAS (Elliott et al., 1983) single word reading test

The mean scores for the good and poor reading groups on each of the measures is shown in Table 24.

Table 24 Mean scores (standard deviations) on preliterate phonological processing and general verbal ability tasks for BAS (Elliott et al., 1983) good and poor reading groups after one year in school

	BAS Reading after one year in school	
Stage 3	Good readers (score>8.00)	Poor readers (score <8.00)
N	39	41
Age	55.64 (1.20)	55.8 (1.25)
Stage 1		
BPVS	47.31 (7.52)	33.51 (9.38)
Allit°	4.28 (2.39)	2.95 (1.38)
RhymeD°	5.69 (2.13)	3.93 (1.98)
RhymeP°	6.03 (4.09)	2.90 (4.23)
Repet°	23.33 (4.84)	24.71 (4.45)
Span°	12.03 (2.48)	10.05 (2.65)

°Raw Scores

Analyses of variance were performed with the BAS reading measure after one year in school as the factor and each of the preliterate phonological awareness and phonological memory measures as dependent variables. The results of these analyses revealed that when general verbal ability was entered as a covariate, the good and poor readers differed significantly on three measures: rhyme detection ($F(1,77) = 6.39$, $MSE = 27.15$; $p < .05$); rhyme production ($F(1,77) = 5.41$, $MSE = 95.38$; $p < .05$); alliteration ($F(1,77) = 5.46$, $MSE = 20.82$; $p < .05$). However, there was no significant difference between the two groups on either of the phonological memory tasks.

Primary (France, 1981) reading test

The mean scores of the phonological processing measures for the good and poor readers assessed by the multiple-choice reading task (France, 1981) are shown in Table 25.

Table 25 Mean scores (standard deviations) on preliterate phonological processing and general verbal ability tasks for Primary (France, 1981) good and poor reading groups after one year in school

	France Primary Reading after one year in school	
Stage 3	Good readers (score>13.00)	Poor readers (score<13.00)
N	37	43
Age	55.92 (1.32)	55.63 (1.13)
Stage 1		
BPVS	43.30 (10.45)	37.60 (10.79)
Allit°	4.03 (2.24)	3.23 (1.80)
RhymeD°	5.65 (2.11)	4.05 (2.07)
RhymeP°	5.73 (4.45)	3.30 (4.14)
Repet°	23.38 (5.24)	19.84 (4.10)
Span°	11.76 (2.29)	10.37 (2.95)

°Raw Scores

Analyses of variance were performed this time with the France Primary reading measure after one year in school as the factor and each of the preliterate phonological awareness and phonological memory measures as dependent variables. These analyses revealed that with general verbal ability entered as a covariate there were significant differences between the good and poor readers. Again, with general verbal ability entered as a covariate, three measures discriminated between the two reading groups: rhyme detection ($F(1,77) = 7.94$, $MSE = 33.11$, $p < .01$); rhyme production ($F(1,77) = 4.03$, $MSE = 71.92$, $p < .05$) and nonword repetition ($F(1,77) = 6.60$, $MSE = 123.85$, $p < .05$).

Nonword reading test (Huxford, 1993)

The mean scores of the good and poor readers assessed by the nonword reading task (Huxford, 1993) for each of the phonological processing measures are shown in Table 26.

Table 26 Mean scores (standard deviations) on preliterate phonological processing and general verbal ability tasks for nonword (Huxford, 1993) good and poor reading groups after one year in school

	Huxford Nonword Reading after one year in school	
Stage 3	Good readers (score>3.00)	Poor readers (score<3.00)
N	40	40
Age	55.62 (1.21)	55.90 (1.24)
Stage 1		
BPVS	44.75 (9.21)	35.75 (10.78)
Allit°	3.87 (2.44)	3.33 (1.53)
RhymeD°	5.65 (2.02)	3.92 (2.10)
RhymeP°	6.10 (4.27)	2.75 (3.96)
Repet°	22.90 (5.02)	20.05 (4.53)
Span°	12.15 (2.43)	9.87 (2.57)

°Raw Scores

For this analysis, the scores for the nonword reading task after one year in school were entered as the factor and each of the preliterate phonological awareness and phonological memory measures were entered as dependent variables. The good and poor reading groups again differed significantly on three measures when general verbal ability was used as a covariate. Significant main effects of group were found on measures of rhyme production ($F(1,77) = 8.30$, $MSE = 140.55$, $p < .01$); rhyme detection ($F(1, 77) = 7.77$, $MSE = 32.50$, $p < .01$) and digit span ($F,(1,77) = 8.48$, $MSE = 51.04$, $p < .01$).

Nonword spelling test (Huxford, 1993)

The mean scores for the good and poor spellers on each of the phonological processing measures are shown in Table 27.

Table 27 Mean scores (standard deviations) on preliterate phonological processing and general verbal ability tasks for nonword (Huxford, 1993) good and poor spelling groups after one year in school

	Huxford Nonword Spelling after one year in school	
Stage 3	Good spellers (score>7.00)	Poor spellers (score<7.00)
N	38	42
Age	55.74 (1.35)	55.79 (1.12)
Stage 1		
BPVS	44.55 (9.55)	36.33 (10.76)
Allit°	4.13 (2.47)	3.12 (1.42)
RhymeD°	5.55 (2.21)	4.10 (2.02)
RhymeP°	6.13 (4.27)	2.88 (4.02)
Repet°	23.37 (4.43)	19.76 (4.83)
Span°	12.03 (2.06)	10.10 (2.97)

°Raw Scores

Further analyses of variance were computed this time entering the scores for the nonword spelling task (Huxford, 1993) after one year in school as the factor and each of the preliterate phonological awareness and phonological memory measures as dependent variables. This time when general verbal ability was used as a covariate, significant differences in performance were noted between the good and the poor spelling groups on four measures: rhyme production ($F(1,77) = 7.84$, MSE = 133.59, $p < .01$); rhyme detection ($F(1,77)=4.77$, MSE = 20.67, $p<.05$); digit span ($F(1,77) = 5.20$, MSE = 32.55, $p<.05$) and nonword repetition ($F,1,77) = 4.71$, MSE = 90.45, $p < .05$). These results show a significant relationship between measures of preliterate rhyme awareness, both measures of preliterate phonological memory and later performance on the nonword spelling task.

The findings from the analyses of variance suggest a significant association between preliterate phonological awareness and single word reading after one year in school. The results from the current longitudinal study differ considerably from those of an earlier cross-sectional study (Gathercole et al., 1991) where phonological memory scores were found to be strongly associated with BAS reading scores when both measures were taken after one year of formal schooling. In that study, however, no association was found between phonological memory and single word reading in the four year old children. It is possible that the association found in the five year old children was simply an artefact of the cross-sectional design and reflected qualitative differences between the children in the two groups.

A significant relationship however was found in the current study between the nonword repetition measure of preliterate phonological memory, rhyme awareness and performance on the multiple-choice reading task (France, 1991) at the end of the first year in school. Comparable results were also reported in the earlier cross-sectional study where a significant association was found between rhyme detection and the France Primary reading measure at age four years and a significant association was found between nonword repetition and multiple-choice reading (France, 1981) scores at age five years (Gathercole et al., 1991).

Performance on the two nonword literacy measures, nonword spelling and nonword reading, appeared to be influenced by preliterate rhyme awareness and preliterate phonological memory.

The second aim of this section of the study was to investigate whether phonological awareness and phonological memory reflect one common phonological processing skill or two unique cognitive abilities.

6.2.2 Are phonological awareness and phonological memory dissociable and reflect separate underlying skills?

The correlation matrix (Table 23) suggested a high degree of correlation between the phonological processing measures. In order to investigate whether phonological awareness and phonological memory are separable skills, a series of principal components analyses was performed on the data.

Factor Analyses

A principal components analysis was used in this section of the study to investigate how the phonological processing variables 'clustered' with different measures of literacy. Following a procedure used in an earlier study (Gathercole, Willis & Baddeley, 1991), a separate analysis was performed for each measure of reading or spelling. In each analysis, the five measures of phonological processing were entered with the individual reading or spelling criterion variable. An example of the communality tables and scree plots are shown at Appendix P and Appendix Q. Table 28 shows the factor loadings on the two factors yielded by factor analysis for each measure of reading or spelling.

Table 28 Factor loadings for phonological processing measures with reading and spelling measures (orthogonal Varimax solutions from factor analysis are shown)

Variable	Factor 1	Factor 2
BAS reading		
Allit	.08	**.79**
Repet	**.76**	.13
RhyD	**.57**	**.52**
RhyP	**.79**	.21
Span	**.84**	.06
Reading	.15	**.74**
Primary Reading (France)		
Allit	.02	**.85**
Repet	**.76**	.13
RhyD	**.56**	**.53**
RhyP	**.81**	.17
Span	**.81**	.14
Reading	.27	**.72**
Nonword Reading (Huxford)		
Allit	.07	**.95**
Repet	**.76**	.04
RhyD	**.59**	**.51**
RhyP	**.79**	.18
Span	**.80**	.09
Reading	**.62**	*.20*
Nonword Spelling (Huxford)		
Allit	.07	**.94**
Repet	**.78**	.04
RhyD	**.57**	**.52**
RhyP	**.77**	.18
Span	**.81**	.09
Spelling	**.67**	.25

Note. Numbers in bold are significant at the 1 per cent level (Burt-Banks, 1947 formula).

The analysis of scores for the single-word reading (BAS; Elliott et al., 1983) is shown in the top panel of the table. With the exception of alliteration, all the phonological measures loaded significantly on the first factor. Alliteration and rhyme detection loaded highly with single-word reading on the second factor. These patterns of association, demonstrated by Factor 1, suggest a degree of commonality between phonological memory and two of the phonological awareness tasks, rhyme detection and rhyme production. In addition, loadings on the second factor propose a specific relationship between single-word reading, alliteration and rhyme detection.

The analysis in the second panel of Table 28, focused on the scores for the multiple-choice Primary Reading Test (France, 1981). With the exception of alliteration, all the phonological measures loaded highly on the first factor. Alliteration and rhyme detection, however, loaded significantly on the second factor together with the reading measure. This repeated the associative patterns revealed by the first analysis where Factor 1 loadings suggest a common phonological processing component, whereas Factor 2 loadings identify a unique relationship between two measures of early phonological awareness (alliteration and rhyme detection) and reading, this time assessed by the multiple-choice task.

The third panel shows the analysis of the data from the nonword reading test (Huxford, 1993) scores and each of the phonological processing measures. This time, phonological memory, rhyme detection and rhyme production loaded highly with nonword reading on the first factor. Alliteration and rhyme detection again loaded on a second factor. These results suggest a common phonological processing component which is closely linked to nonword reading. Despite the unique relationship between alliteration and rhyme detection, demonstrated by the second factor loadings, no association was found between these two skills and nonword reading.

The final panel shows the analysis of the data from the test of nonword spelling (Huxford, 1993) and the phonological processing measures. Both measures of phonological memory, nonword repetition and digit span, loaded highly on a first factor along with rhyme detection and rhyme production. This again may suggest a common phonological processing component which is closely associated with nonword spelling. Factor 2 loadings appeared to confirm a unique association between alliteration and rhyme detection but these two skills were unrelated to nonword spelling.

The factor analyses confirm the earlier proposal of a significant association between phonological memory and two phonological awareness measures, rhyme detection and rhyme production. The results in Table 28 also reinforce the proposal that phonological memory may play a particular role in developing a phonological recoding strategy for reading and spelling. These results also replicate the findings of the last chapter (Chapter 5), suggesting the rhyme detection task may be a measure of both phonological awareness and phonological memory.

6.3 Discussion

The first aim of this part of the study was to assess the relative contribution made by verbal ability and two phonological processing skills, phonological awareness and phonological memory, assessed at a preliterate stage, to literacy after one year in school. Preliminary correlational analysis revealed a significant association between early verbal ability and each of the later measures of literacy.

The data presented here provide further support for the well-documented relationship between early rhyming skills and subsequent literacy (for example Bradley & Bryant, 1983; Bryant et al., 1990). In this study, scores for both the preliterate rhyme detection task and the preliterate rhyme production task were found to be significantly associated with all the later measures of reading and spelling. These findings are entirely consistent with those of another longitudinal study where rhyme awareness was significantly associated with both single-word reading tasks and picture-word matching tasks such as the France Primary reading test (Bryant et al., 1990).

Several influential studies have claimed that early rhyme awareness may precipitate phonological awareness at the phonemic level (for example, Bryant et al., 1990). In the present study, scores for the preliterate phonemic awareness measure, alliteration, were found to be closely associated with later performance on the single-word reading task (Elliott et al., 1983). There is some evidence also that a reciprocal relationship exists between developing phonemic awareness and learning the letters of the alphabet (Adams, 1990; Byrne & Fielding-Barnsley, 1989). From the findings of other studies (for example, Stuart & Coltheart 1988), it would seem plausible that the children who were able to identify single phonemes, that is the children who performed well on the alliteration task, may also have been using some rudimentary 'alphabetic cue' for the single-word reading task. However, in the absence of any context, partial recoding, or the identification of the first one or two sounds in the word, would have been of little assistance in generating the whole word.

It has been argued that a full phonological recoding strategy, matching individual graphemes to phonemes and blending these phonemes into a whole word, is particularly unsuitable for the BAS single word reading task where more than half the first 30 words fail to conform to regular spelling patterns (Gathercole & Baddeley, 1993). Developmental studies of reading suggest that at the earliest stage of reading, salient visual cues are used to match words to their meaning or pronunciation (Ehri, 1995; Frith, 1985). For this reason visual memory skills are thought to be more critical than phonological memory skills (Ellis & Large, 1988). This may in part explain the weak association found between preliterate phonological memory ability and performance on the single-word reading task.

From the analyses of variance, it would appear that performance on the multiple-choice picture-word reading task (France, 1981) was influenced by both measures of preliterate rhyme awareness and one measure of phonological memory, nonword repetition. The association between performance on the nonword repetition task and vocabulary knowledge found previously has been attributed to proficient short term memory function (Gathercole & Baddeley, 1989). Arguably, the multiple-choice reading task, where a phonological representation of the picture to be 'read' is in the first instance supplied either by the experimenter (see Gathercole & Baddeley, 1993) or the child him or herself, is more akin to a spelling than a reading test. For this task, the child has to identify these component sounds and pair the articulated word to one of five alternative printed words. The child who is able to hold this stimulus sound in short term memory, would clearly have some advantage in making appropriate phoneme-grapheme associations over the child with poor phonological memory ability. For half the items in this task, none of the four foil words begin with the same phoneme as the target word and a degree of success (50%) could be achieved by appropriately matching the first phoneme to the first grapheme.

The factor analyses and the analyses of covariance revealed that preliterate rhyme awareness and phonological memory skill are significantly linked to later success on both the nonword spelling and the nonword reading tasks. There is some evidence that young children rely on visual cues to generate the words they use in their early writing (Frith, 1985). However, in a nonword spelling task, no visual representation has been stored and a full phonological recoding strategy is necessary. A full phonological recoding strategy is thought to require a combination of phonological awareness to identify the component sounds in the target word and phonological memory to store these sounds and match them to the appropriate graphemes (Gathercole & Baddeley, 1993). Although success in the nonword spelling task was dependent on full phoneme-grapheme translation, the individual sounds did not have to be stored in memory for subsequent blending as in the nonword reading task. This storage for blending would seem to demand greater or more sophisticated phonological memory skill. This may in part explain why, in line with other studies (for example, Huxford, 1993), the data reported here suggest that children were more able to employ a phonological recoding strategy for nonword spelling, where no blending is required, than for nonword reading.

In line with the findings of an earlier study, the results of factor analyses in the present study suggest that rhyme awareness and phonological memory may share a common underlying skill (Gathercole et al., 1991). This lends some support for the proposal that phonological awareness and phonological memory during the early school years may simply reflect an underlying general phonetic coding skill (Liberman & Mattingly, 1985). The factor analyses reported in this chapter also lend some support to those reported in the previous chapter (Chapter 5) where it was proposed that rhyme awareness and phonological memory at a very young age may be one and the same skill, namely phonological memory. Factor analysis generally aims to identify factors which are relatively independent of one another (Walsh, 1990): the results shown here suggest a clear dissociation between the phonological memory measures and the alliteration measure. If, as in Chapter 5, the Factor 1 variables are taken to reflect underlying phonological memory, the Factor 2 *variables may well* reflect underlying phonological awareness.

Summary

The results presented here would seem to suggest that whereas rhyme awareness plays an important role in all early literacy acquisition, phonological memory may be particularly important as the child moves towards using a full phonological recoding strategy.

It has been suggested that the full phonological recoding strategy assumed to be necessary for fluent, independent reading cannot be achieved until the child has grasped 'the alphabetic principle' (Byrne & Fielding-Barnsley, 1989). The 'alphabetic principle', they claim, can only be acquired though a combination of phonemic awareness and grapheme-phoneme knowledge. The next chapter considers the relationship between preliterate knowledge of the alphabet, phonological processing and subsequent literacy development.

CHAPTER 7

THE CONTRIBUTION OF PHONOLOGICAL PROCESSING AND ALPHABETIC KNOWLEDGE TO EARLY LITERACY

Introduction and Outline of Chapter

The major aims of this longitudinal study were to investigate the relationship between phonological awareness and phonological memory and the relative contribution of these two skills to early literacy. From the factor analyses presented in the previous chapter, it would seem that the Factor 1 variables, namely rhyme awareness and phonological memory, were significantly associated with nonword reading and nonword spelling. As nonwords by definition have no stored lexical representation, the novice reader is presumed to transfer from using a primarily visual strategy to using one of phonological recoding (Ehri, 1995; Frith, 1985; Huxford, 1993). Development of this strategy, according to Byrne and Fielding-Barnsley (1989) requires both phonological awareness and specific knowledge of the associations between individual letters and phonemes. While phonological awareness at the phonemic level enables the child to identify individual sounds within words, phonological memory skills are thought to facilitate learning of the graphemes which consistently represent those phonemes (Gathercole & Baddeley, 1993b).

To date, scant attention appears to have been paid to the relationship between phonological memory skills and alphabetic knowledge during the early stages of literacy development. In order to address this, two measures of alphabetic knowledge, letter-names and letter-sounds, were taken at each stage of testing in the longitudinal study. The data presented here suggest that phonological awareness and phonological memory contribute significantly to the acquisition of alphabetic knowledge. Moreover, children with good phonological memory skill are more likely to learn the letters of the alphabet. The resulting interaction between alphabet knowledge and phonological memory has a highly significant effect on the development of a phonological recoding strategy in reading.

This chapter reports the data on the relationship between phonological awareness, phonological memory and alphabetic knowledge under the following headings

- methodology of the study of alphabetic knowledge
- results
- discussion
- summary

7.1 Methodology of the Study of Alphabetic Knowledge

7.1.1 Aims

It has been suggested from the results of a number of studies that pre-school alphabetic knowledge is the single most reliable predictor of later reading achievement (for example, Blatchford et al., 1987; Riley, 1994). However, as alphabetic knowledge is a learned skill, it has been argued that this association may simply reflect the child's prior 'reading-related experiences' outside school. A causal relationship, Blatchford and Plewis (1990) warn, between early alphabetic knowledge and subsequent reading ability should not therefore be assumed.

This argument has been further endorsed by pre-school intervention programmes which have trained alphabetic knowledge yet failed to replicate the proposed association with subsequent reading (for example, Hohn & Ehri, 1983). Based on findings from these studies, it would appear that although knowledge of letters is important to reading in an alphabetic code (Frith, 1985), it is not sufficient on its own to enhance reading development. Results from a number of intervention studies have demonstrated a significant influence on reading development if training in letter-sound or letter-name learning is combined with training in phonological awareness (for example, Bradley & Bryant, 1983; Byrne & Fielding-Barnsley, 1989, 1991; Hatcher et al., 1994). Results from such intervention studies have prompted claims that only children who are phonologically aware and can segment spoken words into their component sounds will benefit from training in alphabetic knowledge (Tunmer & Hoover, 1992). In support of this claim, Stuart (1995a) found that children who demonstrated good phonological awareness and good alphabetic knowledge during their first school term were more able to use a phonological recoding strategy to read by the end of the first year at school.

These studies suggest that the proficient recoding strategy which may be crucial to independent reading requires both phonological awareness and specific knowledge of the association between individual written letters (graphemes) and sounds (phonemes). However, while phonological awareness enables the child to identify the individual phonemes within words, phonological memory would also seem to play a strategic part at this stage of reading development.

According to Baddeley (1979), phonological memory may contribute to reading development in two ways. Of most relevance to this section of the study, Baddeley suggests adequate phonological memory skills, enable the child to consistently associate graphemes with their corresponding phonemes and, by transferring these to a long term store, acquire alphabetic knowledge. Second, the phonological loop component of phonological memory may act as a buffer store, storing the individual sounds generated by the grapheme-phoneme association process and then enabling the child to blend these sounds together to produce the final 'read' word. From this, it would seem that preliterate alphabetic knowledge may not arise simply from appropriate pre-school literacy experiences but may also be dependent on adequate phonological memory.

The claim that children's pre-reading ability to write in an alphabetic script may be indicative of their subsequent literacy (for example, Riley, 1994) has been discussed earlier (Chapter 1). However, the evidence for this claim comes in part from the children's ability to dictate the constituent sounds in their own names to the experimenter (Riley, 1994). This would seem analogous to a phonological awareness task rather than a test of alphabetic knowledge.

How young children learn the letters of the alphabet is also of interest. One study (Stuart, 1990) interviewed four sets of parents as a 'postscript' to assess the level of home-based teaching which had occurred before the children started school. According to the parents of the three most competent 'segmenters' in the study, their children 'were all encouraged at home to 'write' letters, cards and invitations to friends and family' (p. 146). Activities such as these were not reported for the fourth child who was reported as 'unsuccessful' on a variety of segmentation tasks. A number of studies have already been discussed (Chapter 1) which have specifically considered the influence of instruction on developing literacy (for example, Seymour & Elder, 1986). Based on evidence from a recent study, Stuart (1995a) reports that explicit teaching of the alphabet is often 'upstaged' by contemporary models of instruction (for example Waterland's Apprenticeship Model. 1985). However, Stuart (1995b) emphasises the importance of alphabetic instruction,

> Four and five year olds are also capable of, and benefit from, learning all about letters: what they look like, what their names are, how to write them, what sounds map on to them. (p. 130)

Although instructional methods were not a focus of this study, Stuart's (1995b) comments suggest that some account should be taken of the children's alphabetic experiences in school.

This first aim of this part of the study therefore was to investigate the relationship between preliterate alphabetic knowledge, phonological awareness and phonological memory. The second aim was to examine the contribution made by preliterate phonological memory and phonological awareness to the acquisition of alphabetic knowledge during the first year in school. The third aim was to assess the contribution of preliterate phonological awareness, phonological memory and alphabetic knowledge to literacy development at the end of the first year of formal schooling. The fourth aim was to investigate whether an ability to write in an alphabetic script at a preliterate stage influenced subsequent literacy and finally, to provide some insight into whether alphabetic knowledge is considered to be a priority in the teaching of early reading.

7.1.2 The Sample

The cohort remained the same throughout the study. The mean age of the group and locational details at each stage of testing have been outlined previously (Chapter 5).

7.1.3 Tests and Procedures

Phonological awareness and phonological memory

The materials and procedures for these tests have been described previously (Chapter 5).

Alphabetic knowledge

Alphabetic knowledge was assessed at each stage of the study. Four tests were given: two measured letter-name knowledge and two measured letter-sound knowledge. The materials and order procedures for these tests have also been described earlier (see Chapter 5). In the current chapter the 'auditory presentation tests' refers to the tasks where the letter name or sound was spoken by the experimenter and the child was asked to identify the target letter from a page displaying five printed letters. The 'visual presentation tests' refers to the tasks where the child was shown a page of five letters and had to give the name or sound of the letter pointed to by the experimenter. Based on the analysis of the data from the pilot study described in Chapter 4, the knowledge of letter-names was tested in a different order from the knowledge of letter-sounds.

Write-Name

The procedure and scoring for this task have been described previously (Chapter 4). All the children in the study completed the task to their own satisfaction.

Teaching alphabetic knowledge

The design and procedure for distribution of the two questionnaires has been described previously (Chapter 4).

7.2 Results

This section presents the data which address the five research questions:

- What is the relationship between phonological awareness, phonological memory and alphabetic knowledge at the preliterate stage?
- Do preliterate phonological awareness and phonological memory contribute to the acquisition of alphabetic knowledge during the first year in school?
- If so, do phonological awareness and phonological memory interact with alphabetic knowledge to facilitate the acquisition of literacy after one year of formal schooling?
- Is there a relationship between preliterate phonological awareness, phonological memory and the ability to write in an alphabetic script and is this ability significantly related to subsequent literacy?
- Do teachers consider alphabet knowledge to be important in the acquisition of literacy and do they actively teach alphabet names or sounds?

7.2.1 What is the relationship between phonological awareness, phonological memory and alphabetic knowledge at a preliterate stage?

Mean scores for the measures of phonological awareness and phonological memory were shown previously (Table 13, Chapter 5).

Based on results from the pilot study, low scores were anticipated for the initial assessment of alphabetic knowledge. Table 29 gives the measures of central tendency together with means scores and standard deviations for each of the alphabetic knowledge tasks throughout the study.

Table 29 Mean and median scores for tests of letter-name knowledge (including standard deviations and range) at Stage 1, Stage 2 and Stage 3 of the study

	Letter-names (aural presentation) (max = 26)				Letter-names (visual presentation) (max = 26)				z-value
St	Mean	*sd*	Median	*range*	Mean	*sd*	Median	*range*	
1	8.08	(9.06)	2.50	(0-26)	3.09	(5.26)	1.00	(0-24)	-6.64***
2	16.92	(7.81)	18.5	(0-26)	7.16	(7.67)	3.00	(0-26)	-7.67***
3	22.19	(5.22)	24.5	(7-26)	11.79	(9.32)	9.00	(0-26)	-7.26***

*** $p < .001$

Table 30 gives the measures of central tendency together with means scores and standard deviations for letter-sound knowledge throughout the study.

Table 30 Mean and median scores for tests of letter-sound knowledge (including standard deviations and range) at Stage 1, Stage 2 and Stage 3 of the study

	Letter-sounds (aural presentation) (max = 26)				Letter-sounds (visual presentation) (max = 26)				z-value
St	Mean	*sd*	Median	*range*	Mean	*sd*	Median	*range*	
1	7.32	(8.68)	2.50	(0-26)	3.62	(5.69)	1.00	(0-24)	-6.50***
2	18.58	(7.48)	21.00	(0-26)	12.00	(7.97)	10.50	(0-25)	-7.72***
3	23.81	(4.45)	26.00	(0-26)	19.46	(5.98)	21.00	(2-26)	-6.95***

*** $p < .001$

As predicted, the scores at Stage 1 were low, indicative of floor effects. Furthermore, scores appear to have been equally low for both letter-name and letter-sound knowledge. Performance on the letter-name test was however significantly better with the aural presentation than with the visual presentation. A similar pattern occurred with the scores for letter-sound knowledge. As Tables 29 and 30 demonstrate, when a sign test was applied to the data, the scores for both letter-name and letter-sound knowledge were found to be significantly higher with aural presentation than with visual presentation.

Correlational Analysis

A series of correlations were carried out to examine the relationship between phonological awareness, phonological memory and alphabetic knowledge at the preliterate stage. As before, raw scores were used where scores were found to be normally distributed, but logarithmic transformations were applied to those scores where the distribution was skewed (Tabachnick & Fidell, 1989). This analysis is shown in Table 31.

Table 31 Correlations between phonological awareness, phonological memory and alphabetic knowledge at Stage 1

Alphabetic knowledge	Allit	RhyD	RhyP	Repet	Span
aural presentation					
letter name	.41***	.48***	.42***	.38***	.38***
letter sound	.42***	.46***	.40***	.48***	.44***
visual presentation					
letter name	.25*	.30**	.30**	.19	.10
letter sound	.52**	.35**	.30**	.39**	.36***

* $p < .05$; ** $p < .01$; *** $p < .001$

Alphabetic knowledge and phonological awareness

From the results shown in Table 31, a significant relationship was found between all measures of phonological awareness and all measures of alphabetic knowledge.

Alphabetic knowledge and phonological memory

A significant association was found between both measures of phonological memory, nonword repetition and digit span, and letter-name and letter-sound knowledge when the task was aurally presented. However, no association between phonological memory and letter name knowledge was found when the task was presented in the visual mode.

Table 31 indicated a significant correlation between phonological memory and three of the alphabetic knowledge measures. It would seem plausible to assume that even before formal reading instruction begins, children with good phonological memory ability are more likely to learn the letters of the alphabet than children with poor memories.

In order to investigate this possibility, the sample was subdivided. As most children knew some letters, usually those found in their own names, children with 'good alphabetic knowledge' were those who scored five or more across the tests and the children with 'poor alphabetic knowledge' were those who scored less than five. Both groups were then subdivided based on the children's performance on the memory tasks. A single phonological memory score was derived from the mean scores on the combined Stage 1 phonological memory measures. Children with 'good phonological memory' were those who scored above the mean; children with 'poor phonological memory' were those who scored below the mean.

A chi-square test of independence was used to examine the association between phonological memory and alphabetic knowledge at the preliterate stage. Table 32 shows the result of this analysis.

Table 32 Chi-square analysis of the relationship between phonological memory and alphabetic knowledge at Stage 1

Alphabetic Knowledge	Phonological Memory good *(+ mean)*	poor *(- mean)*	Totals
good *(>5)*	22	7	29
poor *(<5)*	19	32	51
Totals	41	39	80

$\chi^2 = 11.03$, $df = 1$, $p < .001$

Table 32 shows that 41 children from the whole sample (n= 80) scored above the mean for the derived phonological memory score. The table also shows that 22 of these 41 children also performed well on the alphabetic knowledge tasks. The chi-square test carried out on the data was significant at the .001 level ($X^2 = 11.03$, $df = 1$) and confirmed the proposal that preliterate children with good phonological memory ability are more likely to know the letters of the alphabet than children with poor memories.

However, no causal connection could be claimed for the relationship between phonological memory and alphabetic knowledge as almost half the children with good phonological memory (46%; n = 19) were found to have poor alphabetic knowledge. As the chi-square test only determines whether two variables are associated, it provides little information about the direction or strength of the association between the variables. To clarify the meaning of this association a Lambda procedure was used (Goodman & Kruskal, 1954). In this procedure, Lambda values always range between 0 and 1. A value of 0 means the independent variable does not help in predicting the dependent variable; a value of 1 suggests the independent variable can provide a perfect prediction. Table 33 shows the results of this analysis.

Table 33 Lambda analysis of the relationship between phonological memory and alphabetic knowledge at Stage 1

Dependent variable	value (Lambda)	T-value
Phonological Memory	.63	1.85
Alphabetic Knowledge	.20	.21

The results from Table 33 show that when alphabetic knowledge was entered as the predictor variable, the Lambda value of .63 confirmed that children who were successful on the alphabetic knowledge tasks could be reasonably assumed to have good phonological memory ability. However, if a child had good phonological memory skill it would not necessarily follow that he or she would have good alphabetic knowledge. From this analysis, pre-school alphabetic knowledge was not considered to be a valid measure of individual ability as it was impossible to discriminate between children who had poor alphabetic knowledge through lack of ability and those who had poor knowledge through lack of exposure to the alphabet. The results in Table 29 and Table 30 suggest that by Stage 2, when the children had been in school for six months, most were acquiring some alphabetic knowledge. The Stage 2 measures were therefore used as the baseline measure of alphabetic knowledge.

The next section assesses the contribution of these preliterate memory skills and preliterate phonological awareness to the acquisition of alphabetic knowledge during the first year of school when children are introduced formally to reading in an alphabetic code.

7.2.2 Do preliterate phonological awareness and phonological memory contribute to the acquisition of alphabetic knowledge during the first year in school?

Mean scores for the measures of phonological awareness and phonological memory were shown in Table 13 (Chapter 5). Low scores had been anticipated at the first stage of testing for alphabetic knowledge and measures of central tendency, means scores and standard deviations for each of the alphabetic knowledge tasks throughout the study were shown in this chapter in Table 29 and Table 30.

As expected, the children's alphabetic knowledge improved once formal schooling began and appeared to be normally distributed. The tables show that at the pre-school stage, children's knowledge of letter-names and letter-sounds was low. However the children's knowledge of letter-sounds, in both presentation modes, was significantly better than their knowledge of letter names at Stage 2 ($z= 5.97$, $df =79$,; $p < .001$) and Stage 3 ($z=7.64$, $df = 79$; $p < .001$).

Correlational Analyses

Preliminary correlational analyses were used to investigate the relationship between the factor scores for preliterate phonological awareness and phonological memory (as derived from the principal components analysis reported in Chapter 5) and alphabetic knowledge once formal schooling had begun. Different analyses were computed for the letter-name and letter-sound measures. Table 34 shows the results of the correlational analysis for the two factor scores and letter-name knowledge.

Table 34 Correlation of Stage 1 derived factor scores for phonological awareness and phonological memory with letter-name knowledge at Stage 2 and Stage 3

	Letter-name knowledge			
Stage 1	Stage 2		Stage 3	
	aural mode	visual mode	aural mode	visual mode
Phonological Awareness	.41***	.44***	.40***	.41***
Phonological Memory	.37***	.27*	.31**	.40***

*p <.05; **p<.01;*** p < .001

As Table 34 shows, preliterate phonological awareness and phonological memory were both significantly associated with letter-name knowledge once the children started school.

The results of the correlational analysis for the two factor scores and letter-sound knowledge are shown in Table 35.

Table 35 Correlation of Stage 1 derived factor scores for phonological awareness and phonological memory with letter-sound knowledge at Stage 2 and Stage 3

	Letter-sound knowledge			
Stage 1	Stage 2		Stage 3	
	aural mode	visual mode	aural mode	visual mode
Phonological Awareness	.40***	.51***	.31**	.46***
Phonological Memory	.46***	.56***	.28*	.40***

*p <.05; **p<.01; *** p < .001

Table 35 illustrates that preliterate phonological awareness and phonological memory were significantly associated with letter-sound knowledge at each of the follow up stages. As Table 34 and Table 35 suggested letter-sound-knowledge and letter-name knowledge were similarly associated with the phonological processing measures, correlations were calculated for the four measures of alphabetic knowledge at each stage. Table 36 shows the results of this analysis for the Stage 2 measures.

Table 36 Correlation between Stage 2 measures of letter-sound and letter-name knowledge

	Stage 2			
	Letter sounds		Letter names	
	aural mode	visual mode	aural mode	visual mode
Letter sounds				
aural mode	1.00	.88***	.84***	.57***
visual mode		1.00	.79***	.65***
Letter names				
aural mode			1.00	.75***
visual mode				1.00

*p <.05; **p<.01; *** p < .001

At Stage 2, the scores for all tests of alphabetic knowledge were found to be significantly correlated. Table 37 shows the correlations between the Stage 3 measures of alphabetic knowledge.

Table 37 Correlation between Stage 3 measures of letter-sound and letter-name knowledge

	Stage 2			
	Letter sounds		Letter names	
	aural mode	visual mode	aural mode	visual mode
Letter sounds				
aural mode	1.00	.79***	.69**	.35***
visual mode		1.00	.68***	.46***
Letter names				
aural mode			1.00	.62***
visual mode				1.00

*p <.05; **p<.01; *** p < .001

Results from the correlational analysis shown in Table 37 suggest that the four measures were also significantly correlated at the final stage of testing and were therefore assumed to be assessing the same skill, alphabetic knowledge.

In order to investigate the relative contributions made by phonological awareness and phonological memory to alphabetic knowledge a series of path analyses were computed.

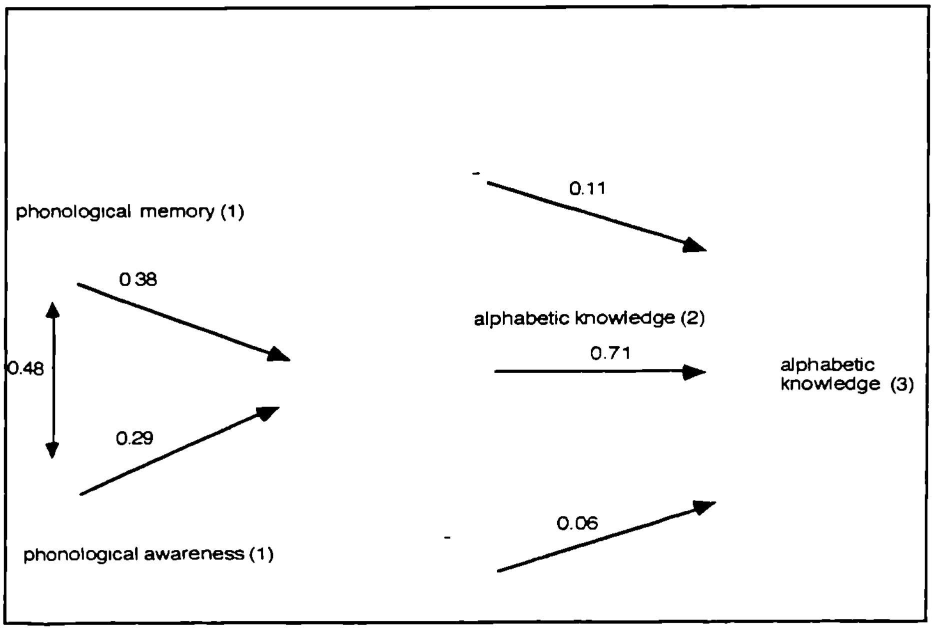
Path Analyses

Path analysis is an extended form of multiple regression and was used to assess the relative contributions of phonological awareness and phonological memory to alphabetic knowledge during the first year in school. The phonological measures entered into this path analysis were the factor scores for the phonological memory and phonological awareness variables (as derived from the principal components analyses described in Chapter 5).

As Table 36 and Table 37 suggested there were significant correlations between the measures of alphabetic knowledge at the second and final stages of testing, a single measure of alphabetic knowledge at each stage was computed from the mean scores.

The path diagram shown in Fig. 8 shows the standardised path coefficients (beta weights) for the paths between Stage 1 phonological awareness and phonological memory with Stage 2 and Stage 3 alphabetic knowledge.

Fig. 8 Path diagram showing the contribution of phonological awareness and phonological memory at Stage 1 to alphabetic knowledge at Stage 2 and Stage 3



Although from these path analyses there appeared to be no direct influence of pre-school phonological skills on alphabetic knowledge at the end of the first year in school, there was clear evidence that both these early phonological skills made significant contributions to alphabetic knowledge by the second stage of testing. As would be expected, alphabetic knowledge at Stage 2 had a highly significant effect on alphabetic acknowledge at the third stage of testing. Claims for an association between phonological awareness and alphabetic knowledge have been previously discussed (Chapter 1) but from Fig. 8 it was evident that preliterate phonological memory made a significant contribution to alphabetic knowledge during the first few months in school.

The chi-square analysis in Table 32 revealed that of the 51 children who had poor alphabetic knowledge at the first stage of testing, 19 of these children had phonological memory scores above the whole sample mean. If, as Fig. 8 suggests, phonological memory plays an important part in developing alphabetic knowledge, it would seem plausible to assume that, once formal instruction was available, the 19 children with good phonological memories would acquire alphabetic knowledge with greater ease than the children who had poor phonological memories. Table 38 shows the Stage 2 and Stage 3 mean scores on the alphabetic knowledge tasks for the children who began school with poor alphabetic knowledge, grouped by phonological memory.

Table 38 Mean scores (standard deviations) for alphabetic knowledge at Stage 2 and Stage 3 for children with poor alphabetic knowledge at Stage 1

	Alphabetic Knowledge *Stage 2* (max = 104)	Alphabetic Knowledge *Stage 3* (max = 104)
Stage 1 Group A (n = 19)	42.47 (21.16)	73.32 (16.76)
Group B (n = 32)	29.88 (14.72)	55.32 (16.12)

Note: Group A = children with good phonological memory at Stage 1
Group B = children with poor phonological memory at Stage 1

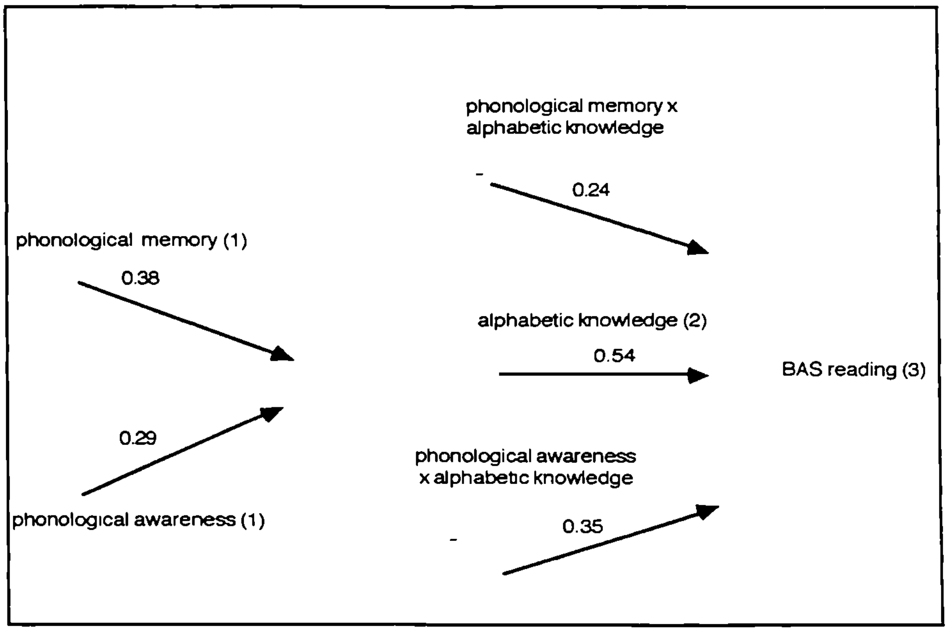
The results in Table 38 demonstrate that, as expected, the mean scores for alphabetic knowledge increased across the duration of the study. In order to investigate whether there was a significant difference in the acquisition of alphabetic knowledge between Group A, the children with preliterate phonological memory skill, and Group B over the first year in school, a one way analysis of variance (ANOVA) was computed. The results of this analysis, with general verbal ability entered as a covariate, showed that acquisition of alphabetic knowledge by the end of the first year in school was significantly better in the children who had good preliterate phonological memories than in the children who started school with poor phonological memory ability ($F(1,50) = 10.55$, MSE 2851.47, $p < .01$).

The next question considered the effects of alphabetic knowledge on subsequent literacy.

7.2.3 Does alphabetic knowledge interact with phonological awareness, and phonological memory to facilitate literacy development?

To investigate the relationship between alphabetic knowledge, phonological awareness and phonological memory, path analyses were again computed. The relationships of phonological awareness, phonological memory and alphabetic knowledge with the measure of BAS reading (Elliot et al., 1983) are shown in Fig. 9. As before, path coefficients (beta weights) have been entered on each path.

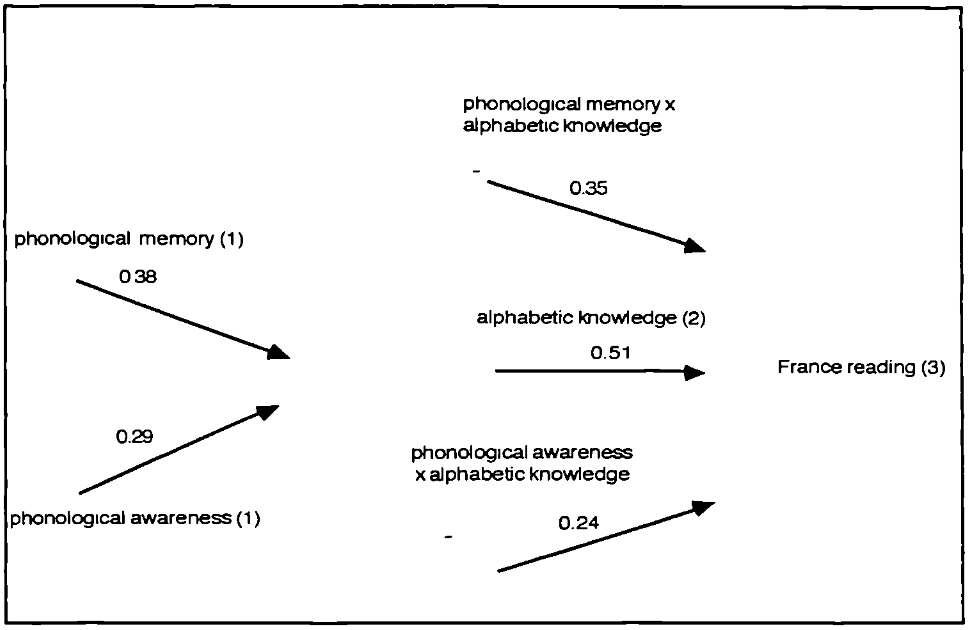
Fig. 9 Path diagram showing the contribution of Stage 1 phonological processing measures, Stage 2 alphabetic knowledge and their product terms to single word reading (BAS; Elliott et al., 1983) at the end of the first year in school



The diagram in Fig. 9 suggests that alphabetic knowledge after six months at school made a significant contribution to single word reading ability by the end of the year. No significant additional contributions were made to the performance on the single word reading test by the product terms 'alphabetic knowledge x phonological memory' and 'alphabetic knowledge x phonological awareness'.

The relationships of phonological awareness, phonological memory and alphabetic knowledge with the multiple choice reading measure (France, 1981) are shown in the path diagram in Fig. 10.

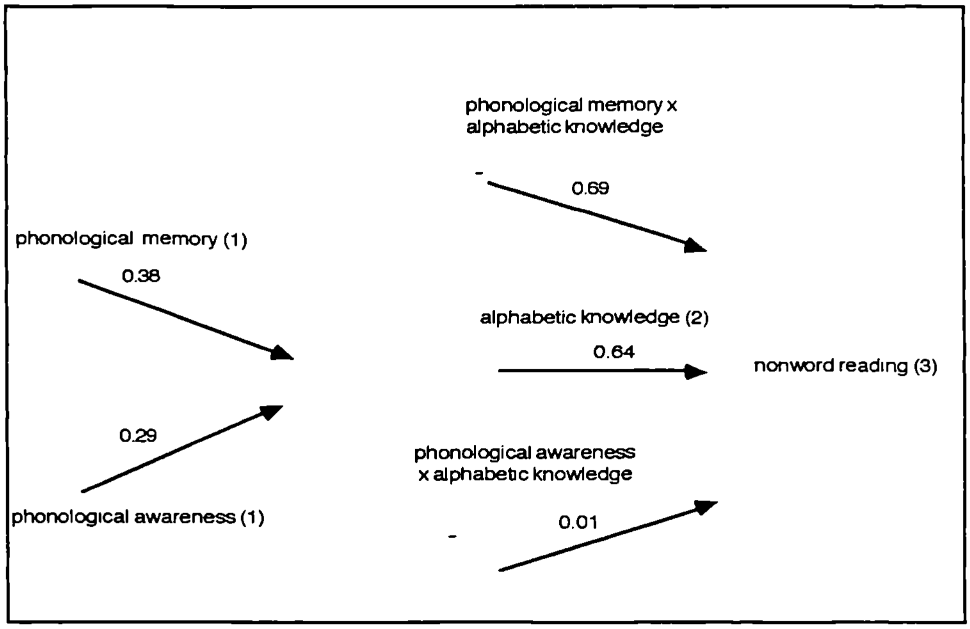
Fig. 10 Path diagram showing the contribution of Stage 1 phonological processing measures, Stage 2 alphabetic knowledge and their product terms to multiple choice reading (France, 1981) at the end of the first year in school



The diagram in Fig. 10 suggests that alphabetic knowledge after six months at school made a significant contribution to multiple choice reading ability by the end of the year. Again the two product terms 'alphabetic knowledge x phonological memory' and 'alphabetic knowledge x phonological awareness' made no additional contribution to later literacy on this measure.

The relationships of phonological awareness, phonological memory and alphabetic knowledge with the nonword reading measure are shown in the path diagram in Fig. 11.

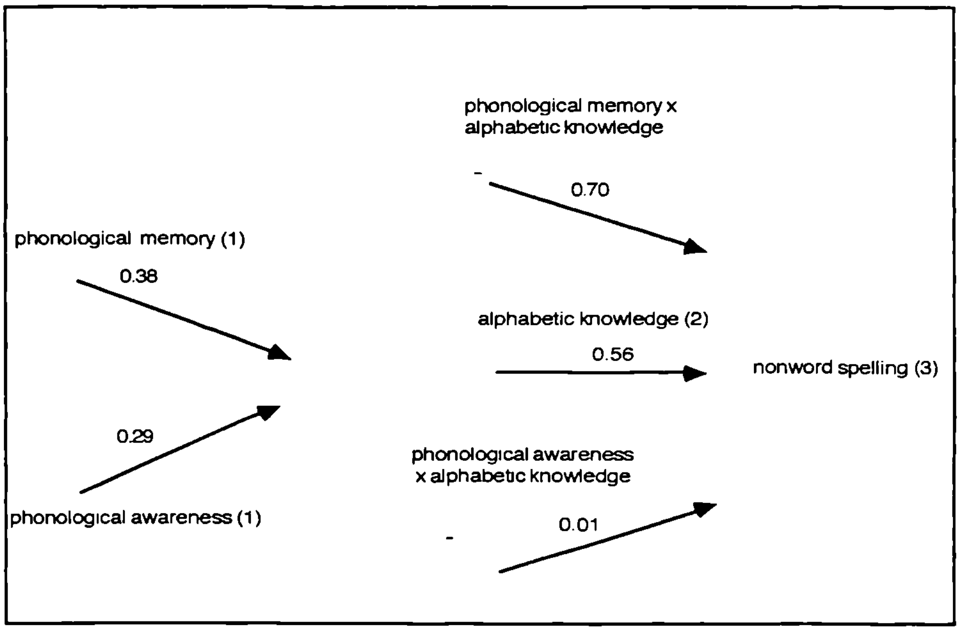
Fig. 11 Path diagram showing the contribution of Stage 1 phonological processing measures, Stage 2 alphabetic knowledge and their product terms to nonword reading (Huxford, 1993) at the end of the first year in school



The diagram in Fig. 11 shows that alphabetic knowledge after six months in school again made a significant contribution to literacy at the end of the first year as measured by the nonword reading task. An additional contribution (5%) was made to the literacy measure by the product term 'alphabetic knowledge x phonological memory'. The product term 'alphabetic knowledge by phonological awareness' failed to enhance the contribution of alphabetic knowledge to nonword reading.

The relationships of phonological awareness, phonological memory and alphabet knowledge with the nonword spelling measure (Huxford, 1993) are shown in the path diagram in Fig. 12.

Fig. 12 Path diagram showing the contribution of Stage 1 phonological processing measures, Stage 2 alphabetic knowledge and their product terms to nonword spelling (Huxford, 1993) at the end of the first year in school



The diagram in Fig. 12 shows again that alphabetic knowledge six months after school entry made a significant contribution to nonword spelling ability by the end of the first year. The association between the product terms and this nonword spelling measure was similar to that demonstrated in Fig. 11. The product term 'alphabetic knowledge x phonological memory' made a further 14% contribution to performance on the nonword spelling task. The product term 'alphabetic knowledge by phonological awareness', as with the nonword reading measure, failed to enhance the contribution of alphabetic knowledge to nonword spelling.

The next section considers the proposed relationship between the children's ability to write their own name before they started school and their literacy skills after one year.

7.2.4 Is there a relationship between preliterate phonological awareness, phonological memory and the ability to write in an alphabetic script and is this ability significantly related to subsequent literacy?

The scoring system for the name-writing task has been described previously (Chapter 4). The results suggested that the scores for the Write-Name task were normally distributed with a mean of 5.30 (max = 10; SD 4.06). None of the children refused to complete the task but several children made no distinction between 'drawing' and 'writing'. For scoring, no account was taken of the case chosen, but one point was awarded if the child began his or her name with an upper case letter: 35 children wrote only in upper case.

Correlational Analysis

A correlational analysis was carried out to investigate the relationship between the children's ability to write their own names, phonological awareness and phonological memory. The derived factor scores for phonological awareness and phonological memory computed in Chapter 5 were used in this analysis. The results are shown in Table 39.

Table 39 Correlation between children's ability to write their own name, phonological awareness and phonological memory at Stage 1

	Phonological Awareness	Phonological Memory
Write-Name	.49***	.32**

*p<.05;**p<.01; ***p < .001

Table 39 suggests that there was a significant association between the children's ability to write their names before they started school and their performance on the early phonological awareness and phonological memory tasks. Although no other studies have assessed this relationship, the association between a child's early ability to write and later literacy has been well documented (for example, Clay, 1989; Riley, 1994). The present study has already discussed the contribution of preliterate phonological awareness and phonological memory to literacy acquisition. Table 40 shows the results of the analysis which considered the relationship between children's ability to write their names, their alphabetic knowledge and their subsequent performance on the four measures of literacy skill.

Table 40 Correlation between Write-Name task and alphabetic knowledge at Stage 1 with reading, spelling and alphabetic knowledge at Stage 3

Stage 1 measures		Stage 3 measures				
	Alphabetic Knowledge	Alphabetic Knowledge	BAS Reading	France Reading	Nonword Reading	Nonword Spelling
Write-Name	.58***	.47***	.44***	.48***	.36***	.46***

*p<.05;**p<.01; p < .001

From these results, it would seem that the children's ability to write their names before they started school was significantly related to their alphabetic knowledge at the same stage. Significant associations were also found between this early writing skill, subsequent alphabetic knowledge and scores on all the reading and spelling measures.

The results presented in Table 29 and Table 30 show that alphabetic knowledge increases significantly once children start formal schooling. The final question focused on teaching by assessing how nursery and reception class teachers viewed alphabetic knowledge and how alphabetic knowledge was taught in the participating schools.

7.2.5 Is alphabetic knowledge considered to be a priority in the teaching of reading and is it taught explicitly during the first year of school?

Two sets of questionnaires were sent; these have been described in Chapter 4 and examples are included at Appendix B and Appendix C. Replies to the questionnaires were received from 15 nursery staff in the eight participating nurseries (max = 18), and 23 reception class teachers in the infant schools (max =27) involved in the project. Both questionnaires asked the staff to rank the skills which were most useful to the beginning reader. The results are shown in Table 41.

Table 41 The ranked importance of pre-reading skills assessed by nursery staff and reception class teachers

Skill	Rank Order most important	——————>			least important
	1	2	3	4	5
Spoken language	33	3	2	0	0
Concepts about print	2	14	16	6	0
Alphabet awareness	0	4	2	17	15
Nursery rhymes	1	14	14	6	3
Write own name	0	2	4	12	20

Note: Each column represents the number of combined nursery and reception year staff (max = 38)

Table 41 shows clearly that the nursery class and reception class teachers attributed very little importance to alphabetic knowledge when asked to prioritise a group of pre-reading skills. The child's ability to write his/her own name was considered by the teachers to be least important in preparing the young child for reading.

The questionnaire also aimed to assess the teaching of alphabetic knowledge by asking the teachers which approaches to reading instruction they most regularly employed. Table 42 shows the results.

Table 42 The ranked regularity of approaches to teaching reading recorded by reception class teachers

Approach	Rank Order most often 1	2	3	4	least often 5
Teaching sight words	10	11	2	0	0
Teaching phonics/sounds	7	10	6	0	0
Teaching alphabet names	2	0	3	18	0
Using child's own writing	3	2	13	5	0

Note: Each column represents the number of reception class teachers (max = 23)

From the information in Table 42, it would appear that the teaching of phonics or sounds is less regular than the teaching of sight words during the reception year. The table also suggests that using the children's own writing as a starting point for reading instruction was not employed regularly by most teachers in the survey. Formal teaching of alphabet names occurred least regularly.

The final question asked the teachers to identify any literacy support techniques used in the classroom. They were also asked to list any television or radio programmes which were regularly watched by the children. Table 43 presents these data.

Table 43 Literacy support techniques used in the classroom together with television and radio programmes watched regularly in school by the children

Literacy Support Methods	Number of schools (max = 23)
Teaching Aids	
McNally Sight Word List	12
Letterland	11
Breakthrough to Literacy	7
TV /Radio Programmes	
Words and Pictures	13
Tat-a-tat-tat	3
Watch	2
Storytime	2
Hotenpot	1
Come Outside	1

The data presented here on literacy support techniques would seem to confirm the information in Table 42: almost half the schools used formal, published programmes for teaching a sight vocabulary and sounds. Thirteen of the 23 schools also watched a weekly television programme, *Words and Pictures,* which introduces letters of the alphabet, their sounds and the corresponding handwriting formation.

7.3 Discussion

Alphabetic knowledge was monitored throughout the duration of this longitudinal study. The results presented here suggest that preliterate phonological awareness and phonological memory contribute significantly to the ease with which children acquire alphabetic knowledge once in school.

These findings support previous claims that phonological awareness facilitates the acquisition of alphabetic knowledge (Cataldo & Ellis, 1990; Jorm & Share, 1983). However, no evidence was found of the interactive contribution of phonological awareness and alphabetic knowledge to real word reading proposed by Muter (1994). Moreover, results from the path analyses would seem to suggest that alphabetic knowledge and phonological memory may have a significant interactive effect on nonword reading and nonword spelling ability after one year in school. Thus it would seem, while phonological awareness and phonological memory play a significant role in the acquisition of alphabetic knowledge, phonological memory interacts with alphabetic knowledge in the development of a phonological recoding strategy. This offers clear support for the proposed contribution of phonological memory to the phonological recoding strategy thought to be necessary in early reading (Gathercole et al., 1991).

In line with the findings of other studies (for example, Stuart & Coltheart, 1988) scores on the pre-school alphabetic knowledge of the children in this study was low but improved noticeably once formal schooling began. No measure was taken in this study of parental intervention before the children started school, so it cannot be assumed that those who lacked alphabetic knowledge had not received any form of instruction. However, it would seem that children with low scores for alphabetic knowledge but good phonological memory at the preliterate stage made rapid progress once in school. The data from this study thus add specific support to the claim that children's phonological memory skills influence their acquisition of alphabetic knowledge (Gathercole & Baddeley, 1993a): the children with good phonological memory before starting school make significantly greater gains in alphabetic knowledge than children with poor early phonological memory skills once formal schooling, and apparently formal instruction, begins.

Throughout the study, performance on the aurally presented tasks was significantly better than on the visually presented tasks. This observation would seem to support the findings of two earlier studies. Byrne and Fielding-Barnsley (1993), from their study of alphabetic knowledge, report that 'We have found that the recognition procedure is more sensitive than the standard recall method' (p. 105). Similar findings from a comparative study of the reading and spelling strategies employed by beginning readers, noted 'children could correctly identify letters for spelling purposes (that is with aural presentation) earlier than they could identify letters for reading purposes (that is with visual presentation)' (Huxford, 1993, p. 146).

In line with studies of the influence of modality on memory function (for example, Hitch & Halliday, 1983), it would seem likely that aurally presented letters gain direct access to the phonological store component of working memory and therefore demand less phonological processing. Visually presented alphabetic tasks, considered by Huxford (1993) to be a skill required in phonemic reading, would seem to demand the generation or retrieval of a phonological representation from the long term memory store and may therefore involve more sophisticated use of the sub-articulatory rehearsal component of working memory. Based on the claim that, in young children, the phonological store component of memory is thought to be fully operational earlier than the articulatory rehearsal procedure (Gathercole & Baddeley, 1993), this could explain the difference in performance observed between the two modalities of presentation.

The results from this section of the study also support claims concerning the importance of instructional methods (Seymour & Elder, 1986). Although alphabetic knowledge was generally rated by the teachers to be of low priority in early reading instruction, letter-sound awareness appeared to be more explicitly taught than letter-name awareness and the children's knowledge of letter sounds was significantly better than their knowledge of letter-names by the end of the year.

Summary

This chapter has reported data which suggest that phonological awareness and phonological memory make significant contributions to alphabetic knowledge. From the results presented here, alphabetic knowledge would seem to play an important role in the development of early reading and spelling skills. However, it would seem that in nonword reading and nonword spelling tasks where, it has been claimed (Ehri, 1995), a phonological or phonetic recoding strategy is necessary, the interaction between phonological memory and alphabetic knowledge is of specific importance.

The data presented here have suggested that children's alphabetic knowledge increases significantly during the first year at school. A similar developmental increase has been reported for speech rate in the early school years and the next chapter considers the relationship between speech rate and measures of early phonological processing.

CHAPTER 8

THE RELATIONSHIP BETWEEN SPEECH RATE AND PHONOLOGICAL MEMORY

Introduction and Outline of Chapter

Two earlier chapters (Chapter 5 and Chapter 6) have reported and discussed the data relating to the relationship between phonological awareness and phonological memory in the light of the developmental changes which are thought to take place around the time children enter school. From the literature, there is some evidence of a developmental association also between phonological memory and actual speech rate. This chapter reports on an investigation which monitored the relationship between phonological memory ability and speech rate in the same group of children from a preliterate stage through the first year in school as they began to learn to read. The results presented here suggest that the relationship between speech rate and phonological memory in these young children changed during the first year of school which could be indicative of developmental changes in memory function.

This chapter reports the data and discussed the findings under the following headings:

- methodology
- results
- discussion
- summary

8.1 Methodology of the investigation into phonological memory and speech rate

From the literature review, it would appear that most studies have assessed the relationship between speech rate and phonological memory cross-sectionally (for example, (Raine et al., 1991; Henry, 1994; Hulme & Tordoff, 1989). The longitudinal design of this study facilitated a developmental investigation of this relationship.

8.1.1 Aims

The short-term memory span of young children has been consistently reported to be quantitatively poorer than the memory span of adults and older children (Dempster, 1985). In recent years, there has been increasing research interest in this discrepancy and the development of memory skills in young children. Much of this research has focused in particular on the relationship between phonological working memory and a range of cognitive skills which are commonly used in the assessment of intellectual ability, for example, reading (Crain et al., 1990), vocabulary acquisition (Gathercole et al., 1992) and language comprehension (Shankweiler, Smith & Mann, 1984). The marked increase in memory span which appears to take place during early childhood has been well documented (for example, Chi, 1976; Hitch et al., 1989a). In an attempt to explain this developmental change in memory span, several studies, discussed earlier in Chapter 2, have adopted the working memory model (Baddeley, 1986; Baddeley & Hitch, 1974 .

According to this model, short-term memory is thought to contain a specific component for the processing of verbal material. This phonological loop component in turn comprises of two slave sub-systems, the time-limited phonological store, where phonological representations are held briefly, and an articulatory rehearsal system which serves to refresh the rapidly decaying items in the phonological store. This rehearsal procedure is believed to take place in real time and therefore items which take longer to rehearse are less likely to be retained in the phonological store. Evidence of a linear relationship in adults between the number of items which can be recalled and the speed at which they can be articulated (Baddeley et al., 1975) has prompted the claim that memory capacity is significantly influenced by the rate at which vocal and thereby subvocal rehearsal takes place. As speech rate increases with age and children have slower speech rates than adults, it has been concluded that the more limited memory span associated with early childhood may be attributed to slower rates of rehearsal.

Despite the range of studies, there is conflicting evidence regarding the use by young children of a subvocal rehearsal strategy. Results from some studies suggest subvocal rehearsal does not develop until around the age of eight years (for example, Conrad, 1971; Flavell et al., 1966). Conversely, other studies have reported a linear relationship between speech rate and memory span in children as young as four years of age (Gathercole & Adams, 1993). However, it has been argued in an earlier chapter (Chapter 2), this association became evident only when a nonword repetition task, rather than a digit span task, was used as the phonological memory measure.

Phonological memory is thought to play two important roles in reading development (Baddeley, 1990), First, by enabling the long term learning of necessary letter-sound correspondences and second, by facilitating the short term blending of the identified phonemes to create the requisite word. It seems feasible that a subvocal rehearsal mechanism may be an essential part in this blending process. Nonword reading tasks demand a full phonological recoding strategy (Ehri, 1995) where individual graphemes are matched to appropriate sounds and these sounds are blended to form the requisite words. Thus a phonological recoding strategy would seem to require proficient use of the phonological store and the articulatory rehearsal components of phonological memory. The exact stage at which individual components of memory function develop may therefore be important factors in early reading development.

Despite some findings of a strong association between speech rate and phonological short-term memory skills in children as young as two and three years of age (Gathercole & Adams, 1993), it has been argued that this may not necessarily indicate that an active subvocal rehearsal strategy is being employed (Gathercole & Hitch, 1993). An alternative explanation for the association is that speech rate may provide a useful index of the efficiency with which representations from the phonological store can be 'translated' into articulatory gestures which govern external speech. Critical differences in children with good and poor memories, according to this hypothesis, relate to the efficiency with which the contents of the phonological store can actually be articulated (Gathercole, Willis & Baddeley, 1994a). Speech rate, it would appear, may either indicate the proficient function of the subarticulatory rehearsal procedure or the adequate functioning of the phonological store. As reading tests typically demand an articulated response, the developmental relationship between phonological memory and speech rate as children learn to read would seem to be of particular interest.

Two main questions underpinned this part of the study. First, does speech rate correlate with memory span in children at a preliterate stage? Second, if such an association does exist, does the relationship between speech rate and memory span change during the first year in school?

8.1.2 The Sample

The sample remained the same throughout the study and has been described previously (see Chapter 5).

8.1.3 Tests and Procedures

Memory Span

Two tests of memory span were given: the digit span test (BAS, Elliott et al., 1983) and the nonword repetition test for children (Gathercole, Willis & Baddeley, 1994). The procedures and scoring for these tests were detailed in an earlier chapter (Chapter 5).

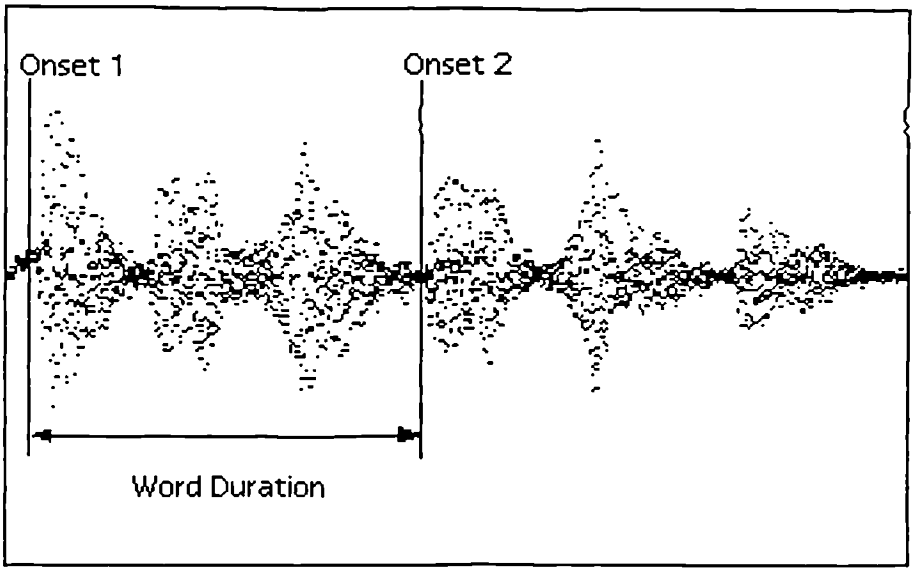
Speech Rate

Based on results from the earlier pilot study (see Chapter 4), the speech rate task was amended to include six items. The first, adopted from the pilot study stimuli, was the monosyllabic word *dog*. The next four items were all adopted from the memory span stimuli. Two nonwords were matched from the nonword repetition task, *diller and pennel*. These two nonwords were appropriate because of their strong plosive onsets and because they were the only two nonwords to have been accurately repeated by a majority of children throughout the study. Two further memory span stimuli, the numbers *1-5* and *4-9*, were taken from the digit span test. The final word, *buttercup*, used as the multisyllabic stimulus, was adopted from two earlier studies of speech rate (Canning & Rose, 1974; Raine et al., 1991) where it had been selected because of its 'rapid alternating movements and use of labial, alveolar and velar sounds' (Raine et al., 1991, p. 418). One previous study had reported the reluctance of young children to participate in tests of speech rate (Gathercole & Adams, 1993); as a knitted doll, *Mr Buttercup* was used to encourage the children in each task throughout the study, the word *buttercup* was considered to be particularly appropriate.

For each item, the child was given the following instructions: 'I would like you to say the word (*dog*) as fast as you can to *Mr Buttercup* until I tell you to stop'. This followed the conventional procedure for obtaining measures of speech rate (Hitch & Halliday, 1983; Hulme, 1984). Observational evidence from earlier pilot trials suggested that individual children responded more favourably to the 'speeded' nature of the task when accompanied by another child; the children therefore worked in co-operative pairs with one child undertaking the task while the other acted as silent but interested observer.

The disparate ways in which speech rate has been measured between studies has been discussed earlier (Chapter 2). In the present study, the children's responses were recorded directly onto a Macintosh Powerbook 540C computer via a clip-on microphone clipped to each child. The computer was equipped with SoundEdit software. The Powerbook had three major benefits for measuring speech rate in this study: the children were highly motivated at both stages of assessment by the opportunity to 'work on a computer'; extraneous sounds and distortion of the audio recording were minimalised by the clip-on microphone and the final audio recording, supported by a clear visual presentation of the child's speech rate provided an easily accessible and durable measure of every item for each child. An example is shown at Fig. 13.

Fig. 13 Oscillogram from individual recording of stimulus word *buttercup* taken at Stage 3



The resultant visual oscillograms were measured from the onset of one word to the onset of the next word using the temporal scale included in the software package. The most rapid item was identified for each trial. It is argued here that a mean score calculated from several repetitions is unnecessary: a child's maximum rate for one repetition must be a valid measure of the fastest speed at which the child can say the stimulus word. The time measure for the most rapid item was then converted to give a mean number of words articulated per second for each trial.

Approximately 25 of the oscillograms were subjected to inter-rater reliability testing at Stage 1 and Stage 3.

8.2 Results

8.2.1 Does speech rate correlate with phonological memory in children at a preliterate stage?

The mean performance of the children at the first assessment point on the tests of speech rate and phonological memory are shown in Table 44.

Table 44 Performance on tests of general verbal ability at Stage 1 together with speech rate and phonological memory at Stage 1 and Stage 3

Tests	4 years			5 years		
	Mean	SD	Range	Mean	SD	Range
Speech rate (words per second)						
dog	3.83	(.64)	(2.44-6.25)	4.53	(.74)	(3.23-7.69)
diller	2.72	(.39)	(1.69-3.57)	3.15	(.45)	(2.22-4.35)
pennel	2.66	(.48)	(1.72-4.00)	3.02	(.50)	(2.00-5.00)
1-5	1.67	(.48)	(0.99-2.27)	2.12	(.31)	(1.41-2.94)
4-9	1.67	(.29)	(1.09-2.33)	2.18	(.30)	(1.39-3.13)
buttercup	1.67	(.31)	(1.03-2.50)	2.07	(.40)	(1.18-3.33)
Phonological Memory (raw scores)						
Span	11.0	(2.74)	(5.00-17.00)	13.80	(3.02)	(6.00-22.00)
Repet	21.5	(4.96)	(9.00-32.00)	29.61	(4.25)	(16.00-39.00)
BPVS	40.24	(10.95)	(21.00-68.00)			

Table 44 gives the mean speech rate in words per second for the children at age four years and at age five years. These mean rates compare well with those obtained from other studies of speech rate at a similar age (for example, Gathercole, Adams & Hitch, 1994; Raine et al., 1991), and this would seem to indicate that the children in this study did view the test as a 'speed-essential' task. As predicted from the studies reviewed earlier in Chapter 2 (for example, Hulme et al., 1984), a t-test confirmed the children's speech rate was significantly faster at the second stage of testing ($p < .001$). A further sign test demonstrated that speech rates were significantly faster for the 1-syllable *dog* than for the 3-syllable *buttercup* ($p < .001$) throughout the study.

Correlational Analysis

The correlations between speech rate and memory at Stage 1 were of central interest to this part of the study. The correlation matrix for the speech rate, phonological memory and general verbal ability scores are shown in Table 45.

Table 45 Correlation between speech rate, phonological memory and general verbal ability at Stage 1

		BPVS	Repet	Span	Dog	Diller	Pennel	1-5	4-9
1	BPVS								
2	Repet	.44**	1						
3	Span	.36**	.53**	1					
4	SR: Dog	.15	.14	.03	1				
5	SR: Diller	.02	.21	.14	.38**	1			
6	SR: Pennel	.08	.21	.15	.57**	.53**	1		
7	SR: 1-5	.02	.22	.10	.44**	.39**	.56**	1	
8	SR: 4-9	.09	.12	.06	.41**	.25*	.46**	.63**	1
9	SR: Buttercup	.23*	.30**	.19	.28*	.41**	.46**	.37**	.38**

* p<.05; **p<.01; ***p < .001.

The significant association shown in Table 45 between each of the speech rate measures is entirely consistent with the findings from an earlier study and is therefore taken to confirm that the test designed for this present study provided a reliable measure of speech rate (Gathercole & Adams, 1994). The consistent significant correlation between the two phonological memory measures and general verbal ability throughout the study has been previously discussed (Chapter 5). General verbal ability was found to correlate with only one measure of speech rate, the multisyllabic word *buttercup*. One of the most interesting features of the current correlation matrix is, however, the correlation between the multisyllabic *buttercup* and the phonological memory measure, nonword repetition ($r = .30$, $p < .01$). No significant association was found between any measure of speech rate and the other measure of phonological memory, digit span.

This pattern of association would seem to suggest that at the first stage of testing, the relationship between phonological memory and speech rate may be influenced by the vocabulary chosen for the speech rate stimuli and the phonological memory measure employed. The next section investigates whether this pattern of association changes during the first year in school.

8.2.2 What is the relationship between speech rate and phonological memory at the end of the first year in school?

The mean scores, standard deviations and ranges for the speech rate and phonological memory measures were shown in Table 44. Table 46 presents the results of the correlational analysis for the preliterate measure of general verbal ability together with the speech rate and phonological memory measures after the children had been in school for one year.

Table 46 Correlation between general verbal ability at Stage 1 and speech rate and phonological memory at Stage 3

	BPVS	Repet	Span	Dog	Diller	Pennel	1-5	4-9
1 BPVS	1							
2 Repet	.37**	1						
3 Span	.43**	.43**	1					
4 SR: Dog	.01	.15	.01	1				
5 SR: Diller	.05	.19	.17	.56**	1			
6 SR: Pennel	.05	.17	.16	.36**	.47**	1		
7 SR: 1-5	.09	.19	.04	.37**	.38**	.29**	1	
8 SR: 4-9	.14	.18	.08	.48**	.38**	.52**	.66**	1
9 SR: Buttercup	.09	.41**	.23*	.43**	.41**	.22*	.35**	

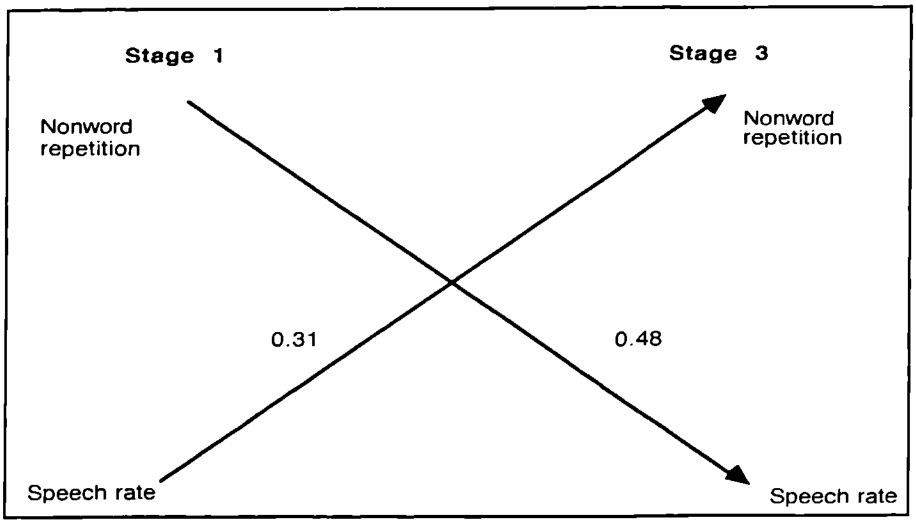
* p<.05; **p<.01;***p < .001.

Significant increases in all measures were found over the duration of the study ($p < .01$, $df = 79$ in all cases). The outcome of the correlational analysis shown in Table 46 indicates there was a change in the pattern of association between the speech rate and phonological memory measures after the children had been in school for one year. General verbal ability while still specifically linked with both the measures of phonological memory, no longer appeared to share an association with any of the speech rate measures. Thus speech rate after one year in school would no longer seem to reflect general verbal ability. A significant association was again found between the multisyllabic measure of speech rate, *buttercup* and the phonological memory measure, nonword repetition. On this occasion a less significant association was also found between the speech rate measure, *buttercup*, and the second measure of phonological memory, digit span.

This correlational evidence that children with a rapid speech rate after one year in school are more likely to perform well on both phonological memory tasks would seem to invite some investigation into the causal structure of the relationship between speech rate and memory span. Causal analysis can offer valuable insight into the relationship between variables (Walsh, 1990). Cross-lagged correlations have been used previously to identify possible causal directions between reading and phonological memory (Ellis & Large, 1988; Gathercole & Baddeley, 1993a) or between phonological memory and vocabulary acquisition (Gathercole et al., 1992).

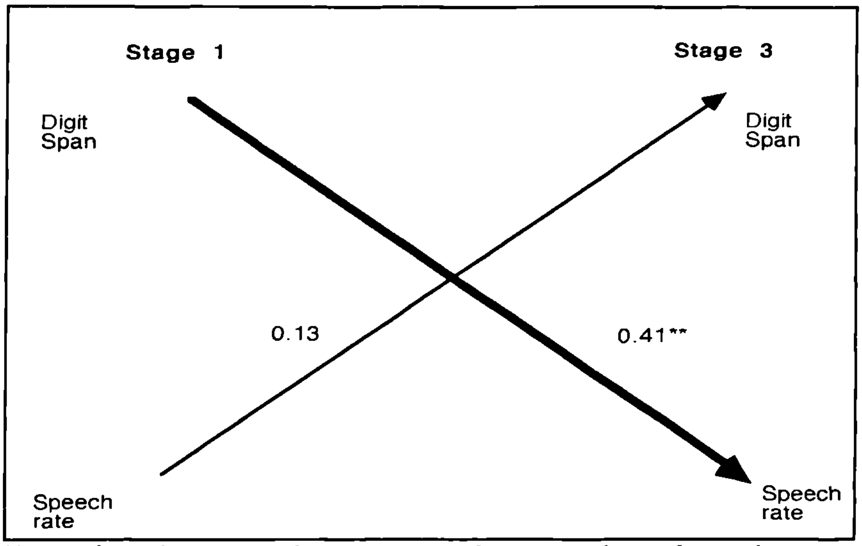
In the present study, both measures of phonological memory, nonword repetition and digit span, were significantly associated with general verbal ability at both stages of testing and partial correlations were therefore computed. The partial correlation procedure is a useful tool for identifying the relationship between two variables while controlling for the effect on both of a third variable (Walsh, 1990). Figure 14 and Figure 15 summarise the results of the partial correlations between the phonological memory and speech rate scores controlling for differences due to general verbal ability.

Fig. 14 Cross-lagged partial correlations between nonword repetition and speech rate controlling for general verbal ability



When a test of the difference between correlation coefficients was applied (Guilford & Fruchter, 1973) to the results in Fig. 14, the correlation between nonword repetition at four years of age and speech rate at five years of age was not found to be significantly different from the correlation between speech rate at four years of age and nonword repetition scores at five years of age. This non significant difference would seem to suggest that there is a reciprocal relationship between these two abilities: early memory skill enhances subsequent speech rate and, conversely, the speech fluency assessed here by the early speech rate measure, may facilitate later memory development. Fig. 15 presents the results of the cross-lagged correlation analysis between speech rate and the digit span measure of phonological memory at the first and final stages of testing.

Fig. 15 Cross-lagged partial correlations between digit span and speech rate controlling for general verbal ability



** significantly greater than corresponding cross-lagged correlation ($p < .001$)

The results shown in Fig. 15 suggest a different pattern of relationship. From this analysis, the correlation between digit span at four years of age and speech rate at five years of age was found to be significantly greater (Guilford & Fruchter, 1973) than the corresponding cross-lag correlation between speech rate at age four years and digit span at age five years ($p < .001$). This pattern of findings would seem to support the notion that phonological memory, when measured by a digit span task, may relate causally to subsequent speech rate.

8.3 Discussion

The aim of this section of the study was to establish whether the significant association found previously between speech rate and memory span in adults was also evident in children around the time they began to learn to read.

This section of the longitudinal study has shown a consistent and significant association between one measure of phonological memory, nonword repetition and speech rate using the stimulus word *buttercup*. The data presented here also suggest that this association between speech rate and nonword repetition strengthens during the child's first year at school. Furthermore, although no significant relationship was found between speech rate and the second measure of phonological memory, digit span, at the preliterate stage, a significant correlation began to emerge by the final stage of testing.

These results both confirm and raise interesting questions about findings from other studies. The current findings would seem to confirm the similar association between speech rate and phonological memory found in an earlier study of very young children aged between two and three years of age. When measures of digit span, word and nonword repetition were used to assess memory function, a significant association was found between speech rate and the two repetition tasks, word and nonword (Gathercole & Adams, 1993).

However, in a later longitudinal study, no association was found between speech rate and phonological memory at the age of four years when only a digit span task was given (Gathercole, Adams & Hitch, 1994). The results of the present study also failed to demonstrate any association between speech rate and a digit span measure of phonological memory at the first, preliterate stage of testing when the children were four years old. However, at a follow-up assessment point in their study, Gathercole and Adams (1994) found significant correlations between speech rate and two measures of phonological memory, nonword repetition and digit span in the group of five year old children. The strength of association, though significant for both, was noted to be weaker between speech rate and digit span ($r = .27$, $p <.05$) than between speech rate and nonword repetition ($r = .47$, $p < .001$). Comparable results were obtained from the present study where speech rate was found to be significantly associated with both measures of phonological memory at five years of age. A similar pattern of association was also found where the association between speech rate and scores on the digit span task were significant ($r = .23$, $p < .05$) but weaker than the association between speech rate and nonword repetition ($r = .41$, $p < .001$).

The two phonological memory tasks were highly correlated throughout the study and have been cited previously as reliable measures of phonological memory (Gathercole & Adams, 1993). Discrepancies between performance on different measures of phonological memory have however been reported previously (Ellis & Large, 1988). Similarly, the results of one study where a digit span measure was used, failed to demonstrate the expected association between phonological memory and vocabulary development. Aguiar and Brady (1991) attributed this 'unexpected finding' to the specific measure of phonological memory employed and suggested a different result may have occurred had a nonword repetition measure been used.

From previous findings of a significant association between speech rate and digit span in five year old children, it has been concluded that young children use a rehearsal strategy (Gathercole & Adams, 1994). This would seem to provide some evidence that digit span tasks may measure a specific component of phonological memory, the subarticulatory rehearsal procedure.

The possibility that the two measures may reflect functioning of different components of phonological memory is an intriguing one. The phonological store component, it has been reported, is thought to become operational at an earlier age than the articulatory rehearsal process. Evidence for this is most commonly found in studies where children as young as four years of age have been found to be sensitive to the acoustic similarity of words (Hulme et al., 1984; Hitch et al., 1989a). This 'phonemic similarity effect' is thought to arise from confusion during input to the phonological store. The articulatory rehearsal process is most typically assessed by the articulatory suppression technique. In this experimental condition, poor recall in serial span tasks is attributed to the disruption caused to the rehearsal process by having to repeat non-relevant words or phrases during presentation of the stimulus material. The apparent immunity to articulatory suppression but sensitivity to phonemic similarity in very young children suggests that the phonological store component of memory is in place prior to the subarticulatory rehearsal process (Henry, 1991b; Gathercole & Baddeley, 1993a)

Nonword repetition has been shown to provide a particularly sensitive measure of phonological memory in very young children (Gathercole & Baddeley, 1990a). In line with the motor theory of speech perception (Liberman & Mattingly, 1985), this measure would seem to appeal to the spontaneous tendency of young children to repeat aloud words they hear. The authors, Gathercole and Baddeley (1993) claim that

> repeating unfamiliar sound sequences is a natural common activity for young children, as part of the process of language acquisition, and the accuracy of repetition seems likely to be less sensitive to the children's use of higher level strategic processes, such as active maintenance or cumulative rehearsal, than in tasks requiring the ordered recall of independent lexical items (p. 49)

According to the working memory model adopted for this study (Baddeley, 1986), such acoustic stimuli would gain direct access to the phonological store. The 'phonological readout' hypothesis proposed by Gathercole and Hitch (1993) emphasises speech rate as a measure of the efficiency with which the contents of the phonological store can be 'read' in an articulatory form. As the nonword repetition task is a single-item task, it demands no serial recall and therefore no list retention. It would seem possible that the young children in this study were not rehearsing but simply responded to the imitative nature of the nonword task. If this were the case, children with more efficient articulatory skill (arguably demonstrated by their speech rate) could clearly be expected to achieve greater success in the task. This may account for the unique association between speech rate and the nonword repetition measure at the first stage of testing.

By the second point of testing, a correlation was also found between speech rate and the serial recall (digit span) task. The serial recall paradigm has typically been used in studies of memory development in young children. As the memory span of a four year old child is thought to be somewhere between two and three digits (Elliott et al., 1983), serial recall tasks of more than two items will presumably benefit from some rudimentary form of rehearsal. Lip-movements in young children have previously been take as evidence of early covert speech (Flavell et al., 1966): in the present study, several children at the final stage of testing overtly articulated the stimulus numbers as they were presented, suggesting the development of an early rehearsal strategy. No measure of the children's familiarity with number was taken in this study, but it could be assumed that counting activities took place regularly in the classroom. It may be that overt classroom-based practice in serial number recall prompted this 'rehearsal' type behaviour after one year in school.

If the two measures reflect different memory functions, how might this account for the apparently different causal associations revealed by the cross-lagged correlations? The different associations suggested by the cross-lagged correlations are puzzling but would seem to reinforce the proposal that the two phonological memory tasks may be reflecting different underlying skills, albeit both memory-based.

One possible explanation for the apparently reciprocal relationship between speech rate and phonological memory (Fig. 14) may be centred in the 'phonological readout' hypothesis. As more speech enters the phonological store during normal language acquisition, so the store becomes more sensitive to the acoustic structure of the input language. As the phonological store grows in sensitivity, so ever-increasing articulatory representations are formulated and these in turn enhance perception of the acoustic structure of language and the whole cyclical process begins again (Liberman & Mattingly, 1985).

The evidence that early phonological memory enhances subsequent speech rate (Fig. 15) may be explained via the 'standard' articulatory rehearsal model. If it could be assumed that, as has been previously suggested, the children who performed well on the initial digit span may have been making some, albeit inconsistent, use of a rehearsal strategy (Gathercole & Baddeley, 1993), this may explain the lack of significant association between early speech rate and phonological memory. If this were the case, then these children may have developed and refined this skill during the first year in school and the speed with which they were rehearsing subvocally may well have been demonstrated by their overt articulation rate at the end of the year.

Summary

This chapter has presented evidence which suggests that two measures of phonological memory may reflect separate components of memory function. The discussion has lent some support to two different theories of the association between speech rate and phonological memory in young children.

CHAPTER 9

SUMMARY AND CONCLUSIONS

Introduction and Outline of Chapter

The literature review (Chapter 1 and Chapter 2) has shown that in recent years a considerable amount of academic interest has focused on the acquisition of literacy in general and, more particularly, on the role played in this process by phonological skills. Evidence from a range of separate studies has shown significant associations either between early literacy and phonological awareness or between early literacy and phonological memory. However, to date, the developmental relationship between these two phonological skills and their relative contributions to literacy appears to have been comparatively ignored.

The longitudinal study reported in the previous chapters was designed to investigate the relationship between phonological awareness and phonological memory and whether these two skills make separate contributions to reading and spelling development.

This final chapter reports and summarises the findings of the study and relates them to current theories of phonological processing and literacy acquisition. These topics are discussed under the following headings:

- the research questions and findings
- methodological considerations
- theoretical implications
- educational implications
- research implications
- conclusion

9.1 The Research Questions and Findings

This section reports the research questions, identifies the main findings and relates the findings to those of previous studies and theories. Where appropriate, this is followed, as Long, Convey and Chadwick (1991) recommend, by the discussion of any 'noteworthy incidental findings which at first do not appear related to the major issue' (p. 156).

9.1.1 The Relationship between Preliterate Phonological Awareness and Phonological Memory

There were three main findings from the preliterate stage of testing. Firstly, nonword repetition, digit span and rhyme production appear to reflect one underlying phonological skill. Secondly, rhyme detection would appear to assess both phonological awareness and phonological memory. Thirdly, when the alliteration was used as the phonological awareness measure, no association was found between the two phonological memory measures, nonword repetition and digit span, and phonological awareness.

The close association previously proposed between preliterate phonological memory and rhyme detection (Gathercole et al., 1991), is confirmed by the findings of this study. Similar evidence from other studies reviewed in Chapter 1 and Chapter 2 has prompted the claim that phonological awareness and phonological memory abilities in young children reflect a general phonetic coding skill (for example, Mann & Liberman, 1984; Shankweiler & Crain, 1986). However, no other study appears to have proposed the significant contribution of phonological memory to rhyme production tasks reported here.

The significant association suggested in this study between rhyme detection and alliteration replicates findings from other studies (for example, Muter, 1994). Previous associations of this nature may, in part, have led to the 'generic view' of phonological awareness as one homogeneous skill.

The consistent dissociation found here between rhyme production and alliteration adds further support to the claim that phonological awareness may be an heterogeneous skill (Bryant et al., 1990). The significant relationship between alliteration and rhyme detection at this stage would also seem to support Treiman's (1991) claim that alliterative tasks reflect phonological awareness at the onset-rime level rather than at the phonemic level suggested by other studies (Muter, 1994; Yopp, 1988).

One other 'noteworthy' finding from this stage of the study confirms the relationship between general verbal ability and phonological awareness (Bowey & Patel, 1988). The significant link found here between phonological memory and general verbal ability has also been previously cited as evidence that good temporary memory skills may enhance vocabulary acquisition (Gathercole et al., 1991). However, the results from this study cannot rule out the alternative possibility that verbal ability, in this instance measured by receptive vocabulary, enhances the development of phonological memory skill.

Summary

Results from measures taken at the preliterate stage suggest that while rhyme production and phonological memory appear to reflect one underlying phonological component, alliteration may be underpinned by a separate phonological processing skill, which could be named 'phonological awareness'.

9.1.2 The Contribution of Phonological Awareness and Phonological Memory to the Early Stages of Literacy

Three main findings arose from this section of the study. Firstly, phonological awareness *and* phonological memory both appear to play an important part in the development of early literacy. Secondly, it seems likely that phonological awareness makes a significant contribution to performance on real word reading tasks. Thirdly, phonological memory seems to contribute significantly to performance on those reading and spelling tasks which demand a phonological recoding strategy.

The results reported here offer direct support for findings from a previous study of the significant but separable contributions made by phonological awareness and phonological memory to early literacy (Gathercole et al., 1991). In line with previous claims (Bryant et al., 1990), the findings from this study suggest a significant association between early phonological awareness measured by a rhyme detection task and subsequent single-word reading. While Bryant and his colleagues found this association to be evident at the end of the second year of schooling, the results presented here suggest that early phonological awareness may have an influential effect on single word reading after only one year in school.

The other measure of word reading used in this study, the multiple-choice reading test (France, 1981), is thought to demand a partial recoding strategy (Gathercole et al., 1991). In order to be able to use this strategy of partial recoding, Ehri (1995) claims, it is necessary for the child to have phonological awareness at the onset-rime level. Findings from this study of a significant association between rhyme detection, alliteration and this measure of reading would seem to suggest that these two measures reflect phonological awareness at the onset-rime level.

The contribution of phonological memory to full phonological recoding in literacy development has been previously postulated but not assessed (for example, Gathercole & Baddeley, 1993a). The results from this study identify the significant contribution made by phonological memory to the two measures of literacy used in this study which demanded a full phonological recoding strategy, nonword reading and nonword spelling.

Several studies reviewed in Chapter 1 and Chapter 2 have proposed that learning to read plays a causal role in the development of phonological awareness and phonological memory (for example Morais et al., 1987; Tunmer & Rohl, 1991). Additional findings from this study suggest there is a significant and progressive development in both phonological awareness and phonological memory once formal schooling and reading instruction begins. However, no causal information can be determined from the data presented here.

Summary

From the data presented here, preliterate phonological awareness and phonological memory were found to make significant but distinguishable contributions to reading and spelling after one year of formal schooling.

9.1.3 The Contribution of Phonological Awareness, Phonological Memory and Alphabetic Knowledge to the Early Stages of Literacy

There were four main findings from this section of the study. Firstly, alphabetic knowledge appears to contribute significantly and directly to reading and spelling development. Secondly, preliterate phonological awareness and phonological memory seem to make significant contributions to the acquisition of alphabetic knowledge during the first year in school. Thirdly, it seems that children who have good phonological memory skills before starting school, may acquire alphabetic knowledge more readily once formal instruction begins. Finally, an interaction between phonological memory skill and alphabetic knowledge contributes significantly to performance on reading and spelling tasks which demand a phonological recoding strategy.

The results from this part of the study offer support to the large number of previous studies which have reported the significant contribution made by alphabetic knowledge to reading and spelling skill (for example, Byrne & Fielding-Barnsley, 1989; 1990). The results here also confirm the relationship between preliterate phonological awareness and alphabetic knowledge (Stuart, 1995) and, at the same time, offer some evidence of the contribution to

alphabetic knowledge by phonological memory inferred previously by Gathercole and Baddeley (1993). This is further confirmed and extended here by data which suggest children with good preliterate phonological memory acquire alphabetic knowledge more readily once formal schooling begins.
The interactive contribution to nonword reading and spelling made by phonological memory and alphabetic knowledge in this study differs from the interactive effect of phonological awareness and alphabetic knowledge proposed by Muter (1994). This may highlight the need for further studies which assess the influence of both phonological processing skills on literacy development.

A number of the findings, although secondary to the main question, also need discussion. As in a number of previous studies (for example, Huxford, 1993; Stuart & Coltheart, 1988), children knew significantly more letter names than letter sounds at the beginning of the study. However, by the end of the first year of formal schooling, this was no longer found to be the case. This finding is in direct contrast to Stuart and Coltheart's final stage findings and therefore seems to warrant more investigation. From the questionnaires completed by the reception class teachers in this study, alphabetic instruction, albeit limited, appeared to be predominantly letter-sound based. This finding suggests that the discrepancy in results between the two studies may be attributed, as Seymour and Elder (1986) suggest to the influence of instructional methods.

Throughout the study, children were able to recognise individual letter names and sound presented aurally, more readily than they were able to recall individual names or sounds with visual presentation. Previous studies of reading development have also noted better performance on alphabetic tasks which ask children to identify letters from aural stimuli than from tasks with visual stimuli which ask them to articulate letter-names or sounds (for example, Byrne & Fielding-Barnsley, 1993; Huxford, 1993). Huxford (1993) suggested this discrepant performance between modalities to be a significant factor in young children's proficiency in using phonemic strategies for spelling where, she argued, the stimulus is aural, before using phonemic strategies for reading where the stimulus is visual. In line with Huxford's findings, scores for nonword spelling in the present study were found to be significantly higher than for nonword reading. An explanation for these findings may be found in the literature on phonological memory research (Chapter 2), where several studies (for example, Hitch & Halliday, 1983) suggest very young children do not employ the same strategies for memory tasks with visual presentation as for memory tasks with aural presentation. Visually presented stimuli, it has been claimed, demand the creation of phonological representations in the subarticulatory rehearsal system (Hitch & Halliday, 1983), which may not be fully functional in very young children (Gathercole & Baddeley, 1993).

The association between preliterate writing ability and subsequent literacy extends earlier findings (for example, Riley, 1994) by showing a significant correlation also between preliterate writing ability, phonological awareness and phonological memory. The association between preliterate phonological awareness, measured by the alliteration task, and writing ability would seem to offer particular support for the claim that early writing can play an important part in literacy development by focusing attention on the individual segments of the written word (Stainthorp, 1989).

Finally, although teachers rated alphabetic knowledge to be of low priority in their teaching, the children's alphabetic knowledge increased significantly during the first year in school.

Summary

The findings from this study indicated that alphabetic knowledge appeared to have made a significant direct contribution to literacy development while the contribution of phonological awareness and phonological memory to early literacy may have been indirect, via alphabetic knowledge.

9.1.4 The Relationship between Speech Rate and Phonological Memory

There were two main findings from this section of the study. Firstly, the association between speech rate and phonological memory appears to differ according to the measure of phonological memory employed. Secondly, it would seem that the relationship between speech rate and phonological memory changes during the first year in school.

The association between speech rate and phonological memory, measured by the nonword repetition task, clearly supports earlier findings of an association in very young children (Gathercole & Adams, 1993). The lack of association between speech rate and the second phonological memory measure, digit span, also confirms earlier findings where this was taken to indicate that young children may not employ subvocal rehearsal strategies in memory tasks (Gathercole et al., 1994a). The longitudinal design of the current study, however, provided some evidence that this pattern of association changed by the time the children had been in school for one year. Results from the final stage of testing suggest a significant association between speech rate and performance on the nonword repetition task together with a significant association between speech rate and performance on the digit span task. These findings are consistent with results from the five year old group in a previous cross-sectional study (Gathercole & Adams, 1994).

Summary

The findings from this section of the study suggest that a quantitative and possibly a qualitative change in memory function takes place during the first year in school. The association found here between speech rate and phonological memory may not necessarily reflect the previously assumed use of a subarticulatory rehearsal mechanism. It may, however, suggest that different measures may reflect efficient functioning of different components of phonological memory.

9.2 Methodological Considerations

Identifying the limitations and possible extensions of a study is, Rudestam and Newton (1992) claim, an essential part of both the discussion and of the preparation for future studies. With the benefit of hindsight, two particular aspects of the present study are reviewed here: the first relates to the sample, the second to the test battery.

9.2.1. The Sample

In view of the practical limitations of the longitudinal design identified in Chapter 3, the children in this study were all already attending some form of pre-school centre. In future studies, it may be possible to extend the findings of this study further by involving children from a broader range of provision, such as some who are at home with a parent or family member, some who are with child-minders and some who are attending occupational nurseries.

Despite the careful design and control of the study, the number of schools participating increased from eight at the first stage of testing to twenty seven at the final stage. This may in part have been caused by current government legislation which permits parents to choose schools for their children. Future studies which are to be undertaken by single researchers may need to consider both optimum sample size and the possible 'spread' of locations at the planning stage.

9.2.2 The Test Battery

The test battery was found to be comprehensive but extensive and further assessment of the children was not considered appropriate. However, some measure of the children's language experiences outside school could have provided more qualitative information about the children's use of nursery rhymes and alphabetic knowledge. Future studies may wish to consider the use of a simple questionnaire for, or interview with, parents or adult carers.

9.3 Implications of the Study

This section evaluates the findings of this study in relation to previous research, relevance for practical application and finally by recommendations for future research.

9.3.1 Theoretical Implications

The results of this study confirm and extend previous findings (reviewed in Chapter 1 and Chapter 2) of a significant association between phonological awareness, phonological memory and literacy.

Phonological Awareness

The clear dissociation of alliteration from general verbal ability suggests that awareness of the initial sound of a word may reflect an unique phonological skill. All the stimulus words in this study contained initial single consonant sounds: as the alliteration and rhyme detection measures appeared to reflect a similar skill, it seems plausible that alliteration tasks of this design may measure phonological awareness at the onset-rime level.

Phonological Memory

A tentative suggestion has been made that different measures of phonological memory may assess different components of memory. The association between speech rate and nonword repetition at four years of age but speech rate, nonword repetition *and* digit span at five years of age would seem to suggest a change in phonological memory function takes place between the two ages. According to the studies reviewed in Chapter 2, it could be expected that at around this time subarticulatory rehearsal becomes more sophisticated and consistent. It would seem plausible that at four years of age, repetition of the word *buttercup* reflects proficient functioning of the phonological store. The stimulus word, *buttercup,* would seem to be similar in phonetic and rhythmic construction to many of the words given in the nonword repetition task and may invoke the same imitative output strategy which, Gathercole and Baddeley (1993) claim, appears to be a 'natural common activity' (p. 49) for young language learners. The significant correlation between general verbal ability, nonword repetition and speech rate at four years of age could suggest that good receptive language before starting school, may enhance or be enhanced by efficient functioning of the phonological store and proficient imitative output skills.

By the age of five, however, the pattern of association changes. The association between speech rate and nonword repetition strengthens and an association with digit span becomes evident. It would therefore seem that after one year in school, more proficient output language strategies at four years of age (measured by nonword repetition and speech rate tasks) may have pre-empted the use of rehearsal strategies (measured by success on the span recall task at five years of age).

These rehearsal strategies, it has been previously suggested (Gathercole & Baddeley, 1993b), are used in early reading to make phoneme-grapheme links, to blend together the phonemes generated in tasks of reading and finally to articulate the appropriate word. It has been previously suggested that rehearsal strategies differ qualitatively between very young children and adults (Gathercole & Baddeley, 1993a). It seems possible that progressive sophistication of subarticulatory rehearsal strategies may be one explanation why some children can make appropriate grapheme-phoneme associations but are unable to blend the generated sounds together to 'read' the requisite word. It may also offer an explanation why some children can spell words they cannot read. It would seem plausible that the aural presentation of the spelling task demands less use of the articulatory rehearsal system for the generation of phonological representations than the visually presented reading task.

Phonological Awareness and Phonological Memory

The consistent association between rhyming and the acquisition of literacy has been noted in the earlier review (Chapter 1) and confirmed by the findings of this study. However, the precise contribution of rhyme to subsequent literacy is still the subject of much research. The findings presented here suggest that rhyme production and phonological memory may reflect the same skill. It could therefore be proposed that the relationship between rhyme and phonological memory may be reciprocal. If the phonological store is fully functional before the subarticulatory rehearsal system, then children's initial repetitive responses arise from a natural imitative strategy. Nursery rhyme games were previously assumed to be a component part of early language acquisition (Trevarthen, 1967). Aitchison (1996) claims the specific value of nursery rhymes lies in their facility for extending the spoken output of young children: children who typically respond at the one or two word level find themselves able to speak four or five consecutive words when they repeat part of a nursery rhyme. Cowan (1992) suggests that it is the duration rather than the speed of recall which reflects phonological memory skill. If the duration of recall is thus seen to reflect subarticulatory rehearsal, then it would seem possible that regular repetition of spoken language, as in nursery rhymes, can develop the use of rehearsal strategies in very young children. Vygotsky (1962) suggests that covert, or internalised speech, can develop only when overt speech is fluently established. Thus, it could be claimed, through external repetition, young children may be developing the skills which underpin the subarticulatory rehearsal strategies which, this study would seem to confirm, is of specific significance in literacy development.

9.3.2 Educational Implications

Cohen and Manion (1992) contend that for too long education has lacked the clear sense of progression evident in other disciplines. The particular value of scientific research in education, they claim, is that it can enable practitioners to develop 'the kind of sound knowledge base that characterises other professions'. In the hope of developing the 'sound knowledge base' further investigations are clearly necessary, but some practical application may be proposed from the findings in this study.

Stuart (1996) advocates that four year olds are 'capable of, and benefit from learning all about letters' (p. 130) and the results from this study would seem to endorse this. Similarly, Stuart's claim that young children need practice in writing would seem to be supported by the findings presented here.

Despite the existence of programmes which claim to enhance reading development (Hatcher et al., 1994) or phonological awareness (Lindamood & Lindamood, 1975), a literature search failed to find evaluations of any published programmes which aimed to enhance phonological memory skills. While there is some evidence that practice in overtly articulating lists can improve performance on phonological memory tasks (for example, Hulme et al., 1984), this does not appear to be used as a typical teaching strategy for developing phonological memory, and particularly subarticulatory rehearsal strategies. However, it could be argued, the most commonly used, albeit unrecognised, teaching strategies for improving phonological memory involve learning nursery rhymes, singing songs and 'cueing' texts from regularly-read storybooks.

9.3.3 Research Implications

'A good study,' Sommer and Sommer (1991) suggest, 'will probably raise more questions than it answers' (p. 298) and a number of areas are identified here as possible areas for future research.

Further studies may be able to identify more specifically the constituent components of phonological awareness by comparing performance on alliteration tasks which use single sounds *and* consonantal blends. As alliteration was also found to be closely associated with alphabetic knowledge prior to formal instruction, further studies may wish to examine any possible causal nature: does alliteration facilitate the learning of the alphabet or does learning the alphabet develop awareness of the component sounds within words? The results of such research could shed valuable light on the causal/consequence debate which until now has remained unresolved by studies of literacy acquisition.

The longitudinal design of this study would seem to be particularly appropriate for monitoring early literacy development. In future research, studies of longer duration, with samples which include both younger and older children, may provide more information on the developmental relationship between phonological awareness, phonological memory at different stages of literacy acquisition.

In the short-term, it would seem of considerable research value to continue to monitor the influence of these early phonological processing skills as the 80 children in this study become independent readers and second-language learners.

9.4 Conclusion

This study suggests that without adequate phonological processing skills, the acquisition of literacy may be impaired by the end of the first year in school. Further research is recommended into the developmental relationship between phonological awareness and phonological memory and the contribution made to literacy acquisition at different stages. At present, it would seem a pre-school battery of tests which involves contemporaneous measures of phonological memory, rhyme detection, rhyme production and alliteration may identify specific stages in the development of phonological processing ability in very young children.

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Proposed rank order for letter-sound acquisition
(from Huxford, 1993; Stuart 1987)

	Huxford (1993)	Stuart (1987)
a	4.5	12
b	18	10.5
d	16.50	10.5
e	16.50	10.5
f	10	8
g	15	17.5
h	8.5	9
i	20	20
j	8.5	3
k	3	2
l	21	19
m	2	4
n	14	16
o	6.5	17.5
p	6.5	6.5
r	11.5	14
s	1	1
t	11.5	5
u	22	23
v	13	13
w	19	15
y	23	22
z	4.5	6.5

Appendix B

CHELTENHAM
&
GLOUCESTER
College of Higher Education

Cornerways
Research Centre
Park Campus
The Park
Cheltenham
Glos GL50 2QF
Tel: (01242) 543489

PRE-SCHOOL LITERACY SURVEY

Name ....

Centre ....

Date ....

Please state your role n the pre-schooler's life (e.g. playgroup leader, playgroup helper, teacher).

....

1. Please list the skills or understandings which you feel are important for the child who is about to learn to read. Then rank them with 1 = most important, 5 = least important.

☐	....
☐	....
☐	....
☐	....
☐	....

2. Which of the following do you consider to be useful to the child preparing to enter school? Again, please rank them 1 = most important, 5 = least important.

☐	Spoken language
☐	Concepts about print
☐	Alphabet awareness
☐	Nursery rhyme knowledge
☐	Ability to write own name

3. Have you heard anything about phonological awareness?

Please return to Terri Passenger at the above address.

Appendix C

CHELTENHAM
&
GLOUCESTER
College of Higher Education

Cornerways
Research Centre
Park Campus
The Park
Cheltenham
Glos GL50 2QF
Tel: (01242) 543489

RECEPTION YEAR LITERACY SURVEY

Name ....

School ....

Date ....

Please state the names of the children involved in the project with whom you have daily contact.

....

....

1. Please list the skills or understandings which you feel are important for the child who is learning to read. Then rank them with 1 = most important, 5 = least important.

☐	....
☐	....
☐	....
☐	....
☐	....

2. Which of the following do you consider to be useful to the child preparing to enter school? Again, please rank them 1 = most important, 5 = least important.

☐ Spoken language
☐ Concepts about print
☐ Alphabet awareness
☐ Nursery rhyme knowledge
☐ Ability to write own name

3. Which of the following literacy support techniques do you employ? Please add any others.

☐ Letterland
☐ Breakthrough
☐ McNally's Sight List
☐ ....
☐ ....

4. Do you regularly watch any TV programmes or listen to any radio broadcasts to support literacy development? Please name the programmes.

☐ ....

☐ ....

5. Which approach(es) to teaching reading do you employ? (If more than one, please rank in order of frequency with 1 = most often, 4 = least often. Please add to the list if you wish.

☐ teaching alphabet names

☐ teaching phonic skills

☐ developing a sight vocabulary

☐ reading-through-personal-writing

☐ ....

Please return to Terri Passenger at the above address.

Appendix D

Stimulus words for main study tests of phonological awareness

Rhyme production

Training items: *egg, drum, gate, jam*

Testing items: *tree, cow, ring, door, shoe, box, pear, rain, duck, comb*

Rhyme detection

Training items:

bus	*car*	*star*
frog	*dog*	*net*
duck	*feet*	*sweet*
key	*book*	*bee*

Testing items:

ball	*sock*	*clock*
hat	*bed*	*cat*
man	*van*	*jug*
nail	*fork*	*whale*
kite	*mouse*	*house*
pin	*tin*	*log*
nurse	*witch*	*purse*
pig	*gun*	*sun*

Alliteration

Training items:

hedgehog	*caterpillar*	*horse*
garden	*gate*	*car*
fork	*wheel*	*worm*
key	*peg*	*kettle*

Testing items:

tiger	*cow*	*cat*
jam	*cake*	*jelly*
table	*television*	*bed*
pig	*fish*	*panda*
apple	*sandwich*	*sausage*
ball	*sock*	*book*
mouse	*monkey*	*jug*
hen	*duck*	*dog*

Appendix E

Item Analysis (from Skurnick & Newell, 1987)

Facility order for presentation

Rhyme detection stimuli

Item Analysis: Rhyme Detection

	Item No	Hi Tally	Lo Tally	F Index
ball	1	7	2	0.64
bed	2	6	3	0.64
man	3	7	4	0.64
nail	4	4	7	0.57
kite	5	7	1	0.57
pin	6	7	0	0.5
pig	7	7	0	0.5
nurse	8	7	0	0.5

Appendix F

Proposed rank order for letter-sound and letter-name tasks

Letter sounds	Letter names
s	x
z	z
m	o
x	s
h	e
r	m
v	w
o	r
c	h
b	b
a	a
e	i
k	t
p	c
t	n
i	u
g	p
n	y
u	g
f	k
w	v
d	f
q	q
l	j
j	l
y	d

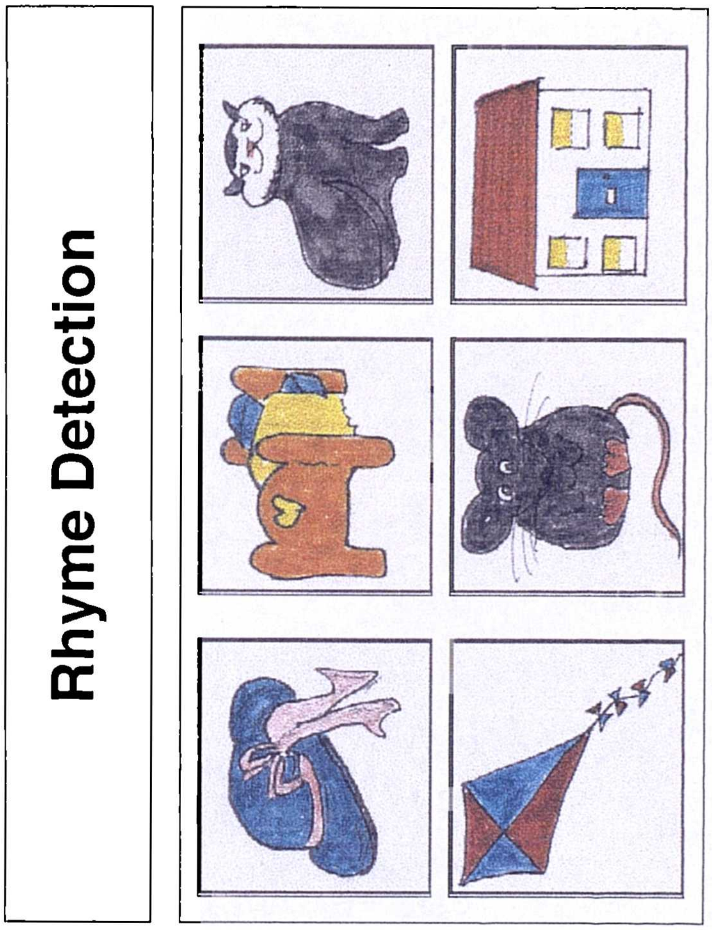
Appendix G

Stimulus words for main study tests of speech rate

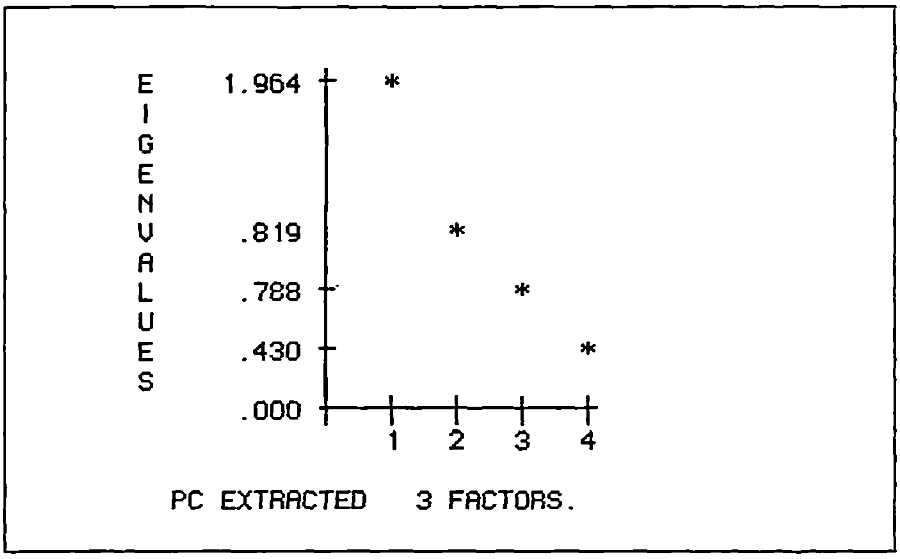
Rationale	Stimulus
monosyllabic	dog
multisyllabic	buttercup
nonword repetition	diller
nonword repetition	pennel
digit span	1-5
digit span	4-9

Appendix H

Example of stimulus pictures for rhyme detection task



Plot of eigenvalues and factors from scree test (Cattell, 1966) of measures of phonological awareness and general verbal ability at Stage 1



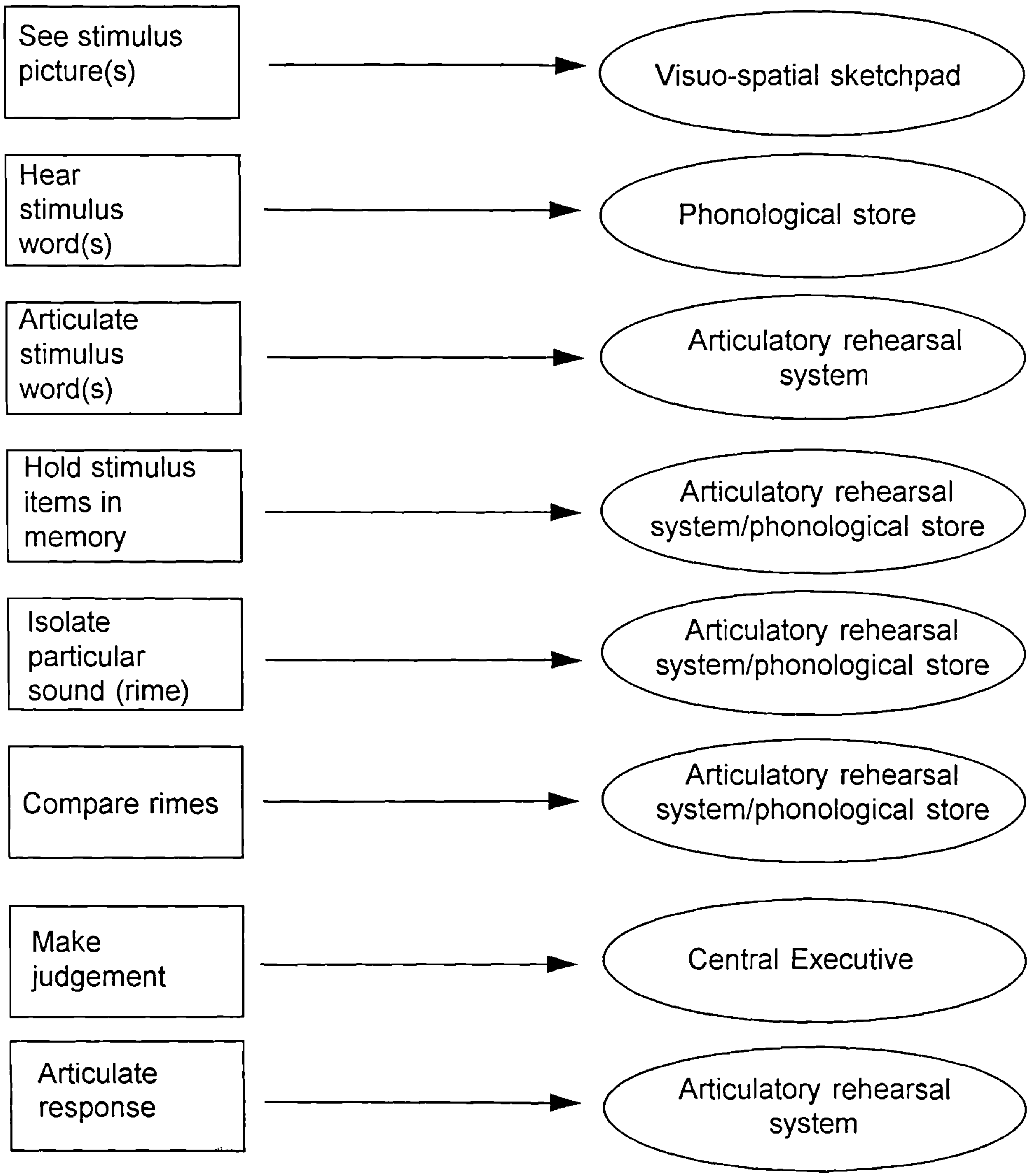
Appendix K

Task analysis for rhyme production

See stimulus picture(s)	Visuo-spatial sketchpad
Encode visual to phonological representation	Articulatory rehearsal system
Articulate stimulus word(s)	Articulatory rehearsal system
Hold stimulus items in memory	Articulatory rehearsal system/phonological store
Isolate particular sound (rime)	Articulatory rehearsal system/phonological store
Isolate particular sound (onset)	Articulatory rehearsal system/phonological store
Identify phoneme in long term store	Articulatory rehearsal system/long term memory
Delete initial phoneme	Articulatory rehearsal system/central executive
Identify alternative phoneme in long term store	Long term memory/ articulatory rehearsal system
Substitute alternative phoneme	Articulatory rehearsal system/central executive
Reblend onset/rime	Articulatory rehearsal system/central executive
Verify from lexicon	Articulatory rehearsal system/long term memory
Articulate response	Articulatory rehearsal system/central executive

Appendix L

Task analysis for rhyme detection



Appendix M

Nonwords used in nonword reading
and nonword spelling tasks
(from Huxford, 1993)

Trial:	**ig**	**tep**
Test:	**ki**	**ep**
	ja	**ik**
	pe	**aj**
	pez	**vok**
	taz	**zep**
	kov	**zat**

Appendix N

Analysis of variance showing effect of phonological awareness and phonological memory on France Primary reading scores (with general verbal ability entered as a covariate)

RhyD1
by France
with BPVS

Source of variation	Sum of squares	DF	Mean square	F	Sig of F
Covariate	37.144	1	37.144	8.906	.004
BPVS	37.144	1	37.144	8.906	.004
Main Effects	33.109	1	33.109	7.939	.006
France	33.109	1	33.109	7.939	.006
Explained	70.253	2	35.126	8.422	.000
Residual	321.135	77	4.171		
Total	391.387	79	4.954		

NWR1
by France
with BPVS

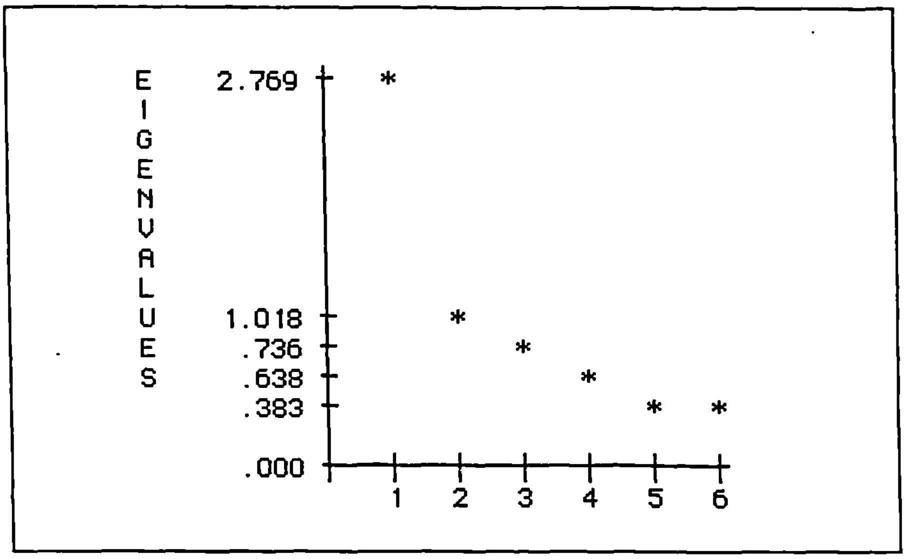
Source of variation	Sum of squares	DF	Mean square	F	Sig of F
Covariate	374.463	1	374.463	19.945	.000
BPVS	374.463	1	374.463	19.945	.000
Main Effects	123.851	1	123.851	6.597	.012
France	123.851	1	123.851	6.597	.012
Explained	498.314	2	249.157	13.271	.000
Residual	1445.636	77	18.774		
Total	1943.950	79	24.607		

RHYP1
by France
with BPVS

Source of variation	Sum of squares	DF	Mean square	F	Sig of F
Covariate	102.245	1	102.245	5.732	.019
BPVS	102.245	1	102.245	5.732	.019
Main Effects	71.923	1	71.923	4.032	.048
France	71.923	1	71.923	4.032	.048
Explained	174.168	2	87.084	4.882	.010
Residual	1373.382	77	17.836		
Total	1547.550	79	19.589		

Appendix P

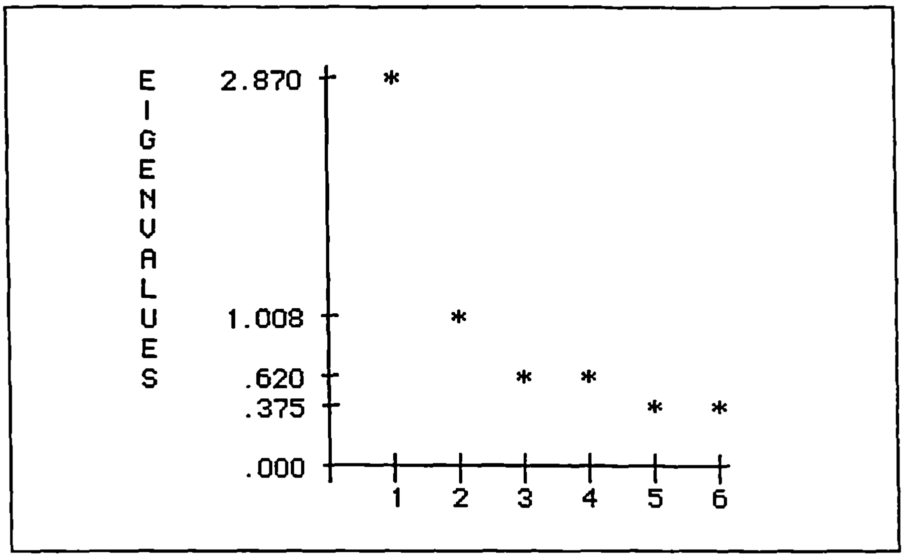
Plot of eigenvalues and factors from scree test (Cattell, 1966) of measures of phonological awareness, phonological memory and single word reading (Elliott et al., 1983)



Factors, communality, eigenvalues and contribution to variance (%) for principal components analysis of measures of phonological awareness, phonological memory with single word reading (Elliott et al. 1983)

Factor	Communality	Eigenvalue	Variance (%)	Cumulative variance (%)
1	.63	2.77	46.2	46.2
2	.57	1.02	17.0	63.1
3	.74	.60	12.3	75.4
4	.59	.64	10.6	86.0
5	.68	.46	7.6	93.6
6	.71	.38	6.4	100.0

Plot of eigenvalues and factors from scree test (Cattell, 1966) of measures of phonological awareness, phonological memory and Primary reading (France, 1981)

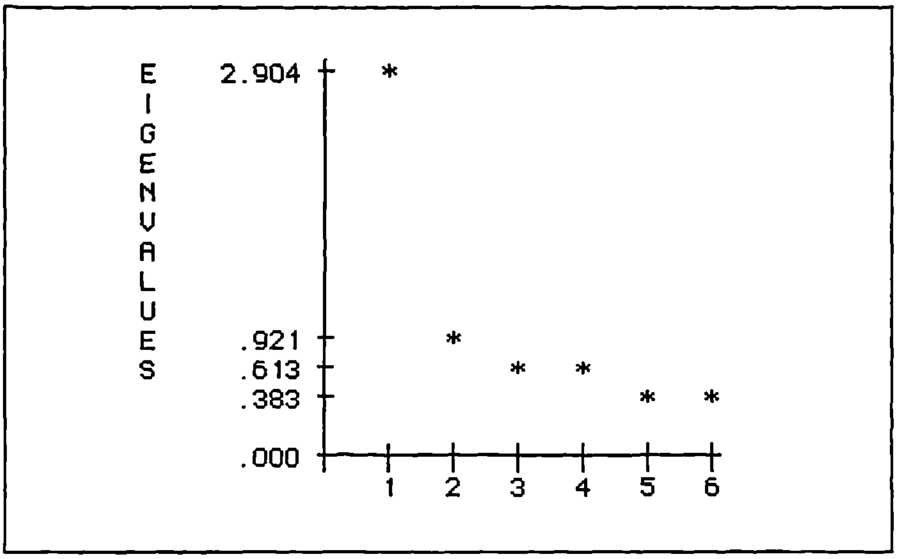


Factors, communality, eigenvalues and contribution to variance (%) for principal components analysis of measures of phonological awareness, phonological memory with Primary reading (France, 1981)

Factor	Communality	Eigenvalue	Variance (%)	Cumulative variance (%)
1	.73	2.90	47.8	47.8
2	.59	1.00	16.8	64.6
3	.60	.66	11.0	75.7
4	.59	.62	10.3	86.0
5	.68	.46	7.8	93.8
6	.68	.37	6.2	100.0

Appendix R

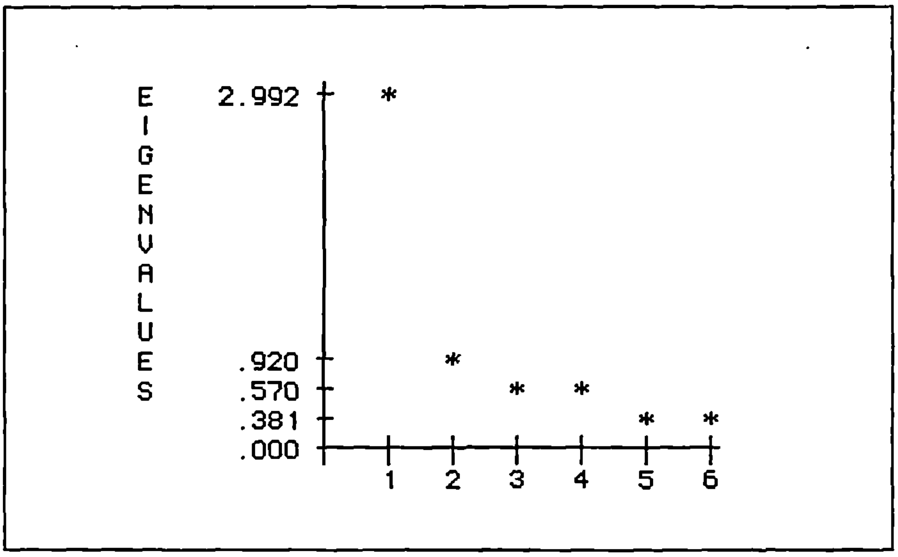
Plot of eigenvalues and factors from scree test (Cattell, 1966) of measures of phonological awareness, phonological memory and nonword reading (Huxford, 1993)



Factors, communality, eigenvalues and contribution to variance (%) for principal components analysis of measures of phonological awareness, phonological memory with nonword reading (Huxford, 1993)

Factor	Communality	Eigenvalue	Variance (%)	Cumulative variance (%)
1	.90	2.90	48.4	48.4
2	.43	.92	15.4	63.8
3	.57	.70	11.7	75.4
4	.61	.61	10.2	85.7
5	.65	.47	8.0	93.6
6	.56	.38	6.4	100.0

Plot of eigenvalues and factors from scree test (Cattell, 1966) of measures of phonological awareness, phonological memory and nonword spelling (Huxford, 1993)



Factors, communality, eigenvalues and contribution to variance (%) for principal components analysis of measures of phonological awareness, phonological memory with nonword spelling (Huxford, 1993)

Factor	Communality	Eigenvalue	Variance (%)	Cumulative variance (%)
1	.89	2.99	49.9	49.9
2	.52	.92	15.3	65.2
3	.61	.67	11.1	76.3
4	.60	.57	9.5	85.8
5	.63	.47	7.8	93.7
6	.66	.38	6.3	100.0